HARLAN LANE & DARYL BEM

# a laboratory manual for the control and analysis of behavior

# A LABORATORY MANUAL FOR THE CONTROL AND ANALYSIS OF BEHAVIOR

# BASIC CONCEPTS IN PSYCHOLOGY SERIES

developed at The University of Michigan
Edward L. Walker, Editor

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# A LABORATORY MANUAL FOR THE CONTROL AND ANALYSIS OF BEHAVIOR

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by Harlan Lane and Daryl Bem

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# SERIES FOREWORD

Basic Concepts in Psychology was conceived as a series of brief paperback volumes constituting a beginning textbook in psychology. Several unique advantages arise from publishing individual chapters as separate volumes rather than under a single cover. Each book or chapter can be written by an author identified with the subject matter of the area. New chapters can be added, individual chapters can be revised independently, and, possibly, competitive chapters can be provided for controversial areas. Finally, to a degree, an instructor of the beginning course in psychology can choose a particular set of chapters to meet the needs of his students.

Probably the most important impetus for the series came from the fact that a suitable textbook did not exist for the beginning courses in psychology at the University of Michigan—Psychology 100 (Psychology as a Natural Science) and Psychology 101 (Psychology as a Social Science). In addition, no laboratory manual treated both the natural science and social science problems encountered in the first laboratory course, Psychology 110.

For practical rather than ideological reasons, the initial complement of authors comes from the staff of the University of Michigan. Coordination among geographically dispersed authors seems needlessly difficult, and the diversity of points of view in the Department of Psychology at Michigan makes the danger of parochialism quite small.

Each author in the Basic Concepts in Psychology Series has considerable freedom. He has been charged to devote approximately half of his resources to elementary concepts and half to topics of special interest and emphasis. In this way, each volume will reflect the personality and viewpoint of the author while presenting the subject matter usually found in a chapter of an elementary textbook.

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## PREFACE: To the Instructor

The student who uses this Manual in a laboratory course in psychology performs experiments that reveal orderly relations between the environment and behavior. The experiments might, in a traditional classification, come under the headings of learning, verbal behavior, sensory measurement, and social behavior, but in conducting them the student learns fundamental techniques of stimulus control and response measurement that are required for the analysis of behavior whatever the problem area. Accordingly, the approach to the experiments—both in the statement of the research problem and in the questions raised for discussion—is systematic rather than eclectic.

Five supplementary features of the Manual enhance its usefulness in the laboratory course. First, the Manual includes a Guide to the Preparation of Laboratory Reports. This Guide, together with the detailed instructions and data forms in each experiment, will aid the student in describing accurately what he did and what he found. Second, the Manual provides a Guide to Laboratory Procedures and Animal Care, including alternative methods of food and water deprivation. Third, the Manual includes a Programmed Introduction to Common Logarithms and Decibels, which provides a more complete understanding of the procedures for measuring stimulus and response in several of the experiments. The program has undergone several tests and revisions.* To complete the program and to conduct the experiments, the student does not need to know statistics or mathematics beyond high school algebra. However, the format of several of the experiments is appropriate for the application of descriptive and inferential statistics.

A fourth adjunct to the experiments described in the Manual is the Guide to Original Research, which will aid the student in formulating and executing a worthwhile experiment of his own design. The fifth supplementary feature is the Evaluation Form accompanying each experiment. When this form is submitted with the laboratory report, the instructor can quickly review his students' progress, and he can detect difficulties that arise with subjects, apparatus, and the like. In several preliminary editions of the Manual, detailed evaluation forms were included to provide data for repeated revision of the experiments. The forms also proved helpful in conducting the laboratory course, so they have been included for this purpose in the final edition of the Manual.

---

* We are indebted to Mr. G. L. Geis and The University of Michigan Center for Research on Learning and Teaching for assistance in revising the program.

The preliminary editions of the Manual have been used over a period of two years by several hundred undergraduates in the elementary laboratory course at the University of Michigan. Each week the student attends one hour of lecture and two consecutive hours of laboratory and, typically, conducts one experiment. In conjunction with the animal experiments, the student completes the first 25 sets of *The Analysis of Behavior* (Holland and Skinner, 1961); for the other experiments, he reads articles from the scientific literature, usually available in the Bobbs-Merrill reprint series. These readings are listed in the references section of each of the experiments in this Manual.

The Manual provides all of the forms and visual materials necessary for the eleven experiments described. One of these experiments requires no other materials; three require only minor apparatus that is readily assembled; and seven require special equipment for conditioning operant behavior or for presenting auditory stimuli. The items of equipment required and a partial list of their suppliers appear below. There is a considerable range in the costs entailed in implementing each experiment, depending on the equipment, manufacturer, and model. An approximate price range is indicated after each heading in the list. The particular items of equipment currently used in the elementary laboratory course at the University of Michigan are indicated by asterisks.

The apparatus required for implementing all of the experiments in this Manual is available as one complete teaching system from

Lehigh Valley Electronics
Box 125
Fogelsville, Pennsylvania 18051
Telephone (215) 285-4211

*Rats* ($2–$5 ea.)

Holtzman Company (421 Holtzman Road, Madison, Wisconsin)
Sprague-Dawley, Inc. (Box 2071, Madison, Wisconsin)

*Cages* ($10–$25 ea.)

Keystone Plastics Company (Media, Pennsylvania)
Welch Scientific Company (1515 Sedgwick Street, Chicago, Illinois)

*Food*

For maintenance: ($3–$7 per K) Ralston Purina Company (Checkerboard Square, St. Louis, Missouri) *
For conditioning: ($.60–$1.50 per K) P. J. Noyes Company (Main Street, Lancaster, New Hampshire), Type 45 mg.*

*Operant-conditioning chambers* ($35–$500)

Davis Scientific Instruments (12137 Cantura Street, Studio City, California)
Farrall Instruments (Box 658, Grand Island, Nebraska)
Foringer and Company, Inc. (Rockville, Maryland)
Ralph Gerbrands Company (8 Beck Road, Arlington, Massachusetts), Model A *
Grason-Stadler Company, Inc. (West Concord, Massachusetts)
Lehigh Valley Electronics (Fogelsville, Pennsylvania)
Psychological Instruments Company (Box 6113, Richmond, Virginia)
Scientific Prototype Manufacturing Corporation (623 West 129th Street, New York, New York)
C. H. Stoelting Company (424 North Homan Avenue, Chicago, Illinois)

*Cumulative recorders* ($150–$400)

Davis Scientific Instruments
Easee Products (Box 75, Tenafly, New Jersey)
Farrall Instruments
Ralph Gerbrands Company, Model C-3 *
Lehigh Valley Electronics
Scientific Prototype Manufacturing Corporation

*Audio-frequency generators* ($40–$400)

Allied Radio Corporation (100 North Western Avenue, Chicago, Illinois)
General Radio Company (West Concord, Massachusetts)
Heath Company (Benton Harbor, Michigan)
Hewlett-Packard Company (1501 Page Mill Road, Palo Alto, California), Model 200-AB *
Lafayette Instrument Company (Box 57, North 26th Street, Lafayette, Indiana)
Marietta Apparatus Company (Marietta, Ohio)
C. H. Stoelting Company

*Attenuators* ($75–$125)

Daven Company (Livingstone, New Jersey), Models T-691,* T-349-G *
Hewlett-Packard Company

*Vacuum-tube voltmeters* ($25–$250)

Allied Radio Corporation
Eico Company (33-00 Northern Boulevard, Long Island City, New York)
Heath Company
Hewlett-Packard Company
Simpson Electric Company (5200 West Kinzie Street, Chicago, Illinois), Model 715AC *

*Earphones* ($30–$100)

Allied Radio Corporation
Grason-Stadler Company, Inc., Model TDH-39 *
Rye Sound Corporation (1113 North El Centro, Hollywood, California)
Roanwell Corporation (180 Varick Street, New York, New York)

*Chronoscopes* ($60–$120)

Lafayette Instrument Company
Meylan Stopwatch Corporation (264 West 40th Street, New York, New York)
Psychological Instruments Company, Model S-1 *
Standard Electric Time Company (Springfield, Massachusetts)

# ACKNOWLEDGMENTS

Although we have assumed responsibility for preparing and revising this Laboratory Manual, the credit for whatever success it may have in introducing the student to experimental psychology must go largely to others:

To the teaching fellows in Psychology 110, University of Michigan, who supervised the conduct of the experiments and aided in their revision.

To the Department of Psychology, Columbia College, on whose many years of experience in teaching an elementary laboratory we have capitalized.

To the students of Psychology 110, whose successes, failures, criticisms, and enthusiasms have guided us throughout.

HARLAN LANE
DARYL BEM

# IN BEHALF OF SYSTEM *

Years ago, in his *Beginner's Psychology* (1915), Titchener, the structuralist, gave the following advice to his readers. He said:

> [Psychology] has only recently turned to scientific methods; and when the time came for it to take its place among the sciences, there was naturally difference of opinion regarding the standpoint it should assume, the procedure it should follow, the model it should seek to copy. When such differences of opinion obtain, the best way to begin your study is to *master one system thoroughly;* your ideas are thus made consistent and your knowledge receives an orderly arrangement; then, as you read further, you can use this system as a touch-stone whereby to test new ideas and to arrange new knowledge; and if the new ideas seem preferable to the old, or if the old framework breaks down under the new knowledge, you can alter your system accordingly. If you begin, on the contrary, by studying a number of works abreast, you are liable to become confused. And it is better to be wrong than muddled; for truth, as Bacon said, emerges more quickly from error than from confusion.

This was wise counsel in 1915, and it is even wiser counsel today, when we have so much new material, such a wide range of facts, to contend with in our science. It is important, both practically and theoretically, to organize your knowledge, especially if your first course in psychology is also to be your last one. The person who takes away from his first course nothing more than a large body of disconnected and sketchily examined items of fact, method, or theory has only a superficial and temporary advantage over the person who never attended the course. If, on the other hand, the student has acquired a systematic orientation, he should have learned to *think* psychologically about everyday affairs as well as those of the classroom or laboratory. His approach to new problems should be more direct and incisive; his estimates of the significance of new findings should be more telling; and he should be less disturbed by the claims of quacks, or blinded by the dust of popular fancy.

As a beginner in psychology, you need not fear that your study of a system of behavior will either restrict your movement or narrow your vision. The opposite is more nearly true. A thorough understanding of a system will increase both the quality and quantity of your productive activity, and it will open up more exciting realms of thinking and discovery than you have ever known. In brief, it will give you a *power* and *perspective* that no other approach to psychology could possibly provide.

---

* From F. S. Keller, *Supplementary Notes*, Psychology 1–2, Columbia College, 1956.

# A GUIDE TO THE PREPARATION OF LABORATORY REPORTS

The goal of scientific writing is effective communication. An experimental report is precise and to the point; it states the question to which the experiment is addressed, the method employed, the results obtained, and the relation of these results to other scientific knowledge. In addition, the usual requirements of English expository prose—such as complete sentences, accurate spelling, and correct grammar—apply to every research report. The following outline, based on the recommendations of the American Psychological Association,* may be used as a guide to organizing and preparing laboratory reports.

## ABSTRACT

An abstract of 120 words or less begins each report of research. "An abstract of a research paper should contain statements of (a) the problem, (b) the method, (c) the results, and (d) the conclusions. Results are most important, and every abstract should contain at least the trend of the results. It is also highly desirable to state the number and kind of subjects, and the kind of research design. . . ." As an example:

> Conditioning Barpress in the Rat
>
> A male albino rat, deprived of food for 23 hours, was placed in a standard experimental space for operant conditioning. First, the operant level of responding was observed: the rat pressed the lever five times in 30 minutes. Then the rat was conditioned to approach the food tray, following the click of the reinforcement dispenser, and to consume a pellet, which was dispensed a variable number of seconds (average, 10) after the last pellet had been consumed.
>
> After 30 pellets had been dispensed, the experimenter presented reinforcement only when a barpress occurred. The rate of barpressing then rose to an average of five responses per minute in the next half hour.

## PROBLEM

The report proper begins with a statement of the problem investigated. "An adequate exposition of the problem should state the questions asked and the reasons for asking them. In reports of theory-testing experiments, the exposition should state the theoretical propositions from which the hypotheses to be tested are derived, give the logic of their derivation, summarize the relevant arguments and data, and state formally the hypotheses to be tested." Here, too, the writer gives credit to other investigators who contributed to the background of the problem. (The introduction to each experiment in this Manual is not intended to replace the student's own statement of the research problem.)

---

* *Publication manual* (Washington, D.C.: American Psychological Association, 1957). For sample articles reporting research, see current issues of the psychological journals—e.g., *The journal of experimental psychology.*

## METHOD

This section is usually divided into Subjects, Apparatus, Procedures, and other headings appropriate to the particular report. The entire section provides enough detail to permit full interpretation, extension, or replication of the experiment. The section contains the number, kind, and relevant characteristics of the subjects employed, along with their participation in related experiments.

The experimenter describes the components and assembly of the equipment used for stimulus presentation and response measurement—including, in parentheses after each item, the manufacturer and model number. The experimenter reports only those features of the apparatus which might be relevant to the control or analysis of the subject's behavior. Standard equipment, such as the typical experimental space for operant conditioning, need not be described in detail; in these cases, a reference is often given to a description in the literature.

The procedure also includes a description of any pre-experimental treatment of the subject (e.g., food deprivation), operations performed during the experiment, stimulus materials presented, and techniques of data collection. (The procedural instructions in this Manual are not intended to replace the student's own statement of method.)

These standard abbreviations are used: *S* for subject, *Ss* for subjects, and *E* for experimenter. The third person, past tense, active voice is typically used in describing the procedure.

## RESULTS

In the text of his report, the experimenter presents results in quantitative form and supports them in greater detail in graphs or tables. He avoids two extremes: (1) He does not simply tabulate the raw data, forcing the reader to analyze them. (2) He does not simply present qualitative descriptions—such as "The rate of barpress increased." Instead, he gives averages, percentages, and representative values where appropriate—for example, "The reinforcement schedule raised the rate to 18 barpresses per minute—an increase of 39%." Also, in the text accompanying a graph, he indicates general trends and unusual deviations.

The experimenter presents in tables all the raw data obtained in the experiment, as well as all derived data referred to in the report (such as totals and averages). Tables are always referred to by Arabic numerals and take the following form:

**Table 1**

Title

| | Box head |
|---|---|
| Stub | Body |

The data appear in the body of the table, and the box head and stub indicate various categories of data. The units of numbers used are always indicated. Columns and rows in the body of the table are separated by light lines, or tabular paper may be used. The title of the table briefly but precisely indicates the nature of the experiment, the subjects employed, and the data presented—e.g., not "Auditory Threshold" but "Threshold Intensities of a Pure Tone at Eight Frequencies, Determined by the Method of Adjustment for One Subject."

Like tables, figures are referred to by arabic numerals. Figures take the following form:

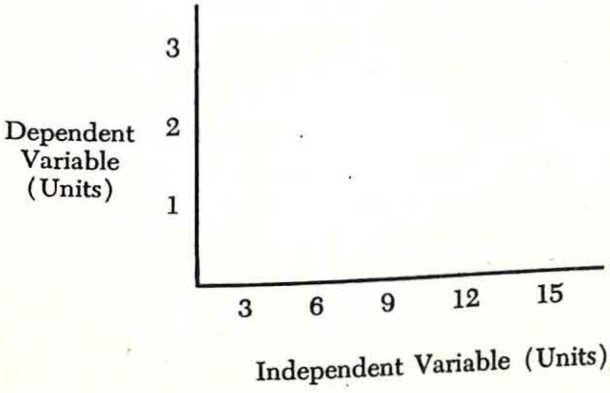

**Figure 1** (Caption)

The axes of the figure are always labeled, and the units of measurement are indicated. The vertical axis ($y$-axis) represents the dependent variable (a measure of the subject's behavior) and the horizontal axis ($x$-axis) the independent variable (such as time, operations performed on the subject, and stimulus magnitude). The caption of a figure, like the title of a table, is brief but comprehensive. The points in a figure are indicated by dots or circles, and any labeled points are explained in the caption—e.g., "At *a*, extinction began." Where more than one curve is presented on the same set of axes, points may be distinguished by squares, circles, etc., and lines by dots or dashes. The curves are distinguished by descriptive labels located on the graph or in a legend—e.g., "Noise, 10 db," not "Group A." Straight lines connect the points in a figure, unless theoretical reasons indicate that a particular mathematical curve should be drawn.

## DISCUSSION

The discussion section may be presented separately or, if appropriate, may be included in the previous section, which is then headed "Results and Discussion." In either case, the discussion relates the findings of the experiment to findings reported by other investigators. Furthermore, the discussion "points out the limitations of the conclusions, notes correspondences or differences between the findings and widely accepted points of view, and briefly gives the implications for theory or practice." The experimenter may draw inferences from the results of the experiment and give alternative interpretations, but he bases his discussion firmly on the findings of the research.

## REFERENCES

The bibliography at the end of the report includes only references cited in the text. References after experiments in this Manual illustrate the correct format—for example, pages 44, 53, and 244.

In addition to the standard format described above, a laboratory report includes the original forms on which the data were recorded, since another person may discover additional results in the raw data and thus may uncover a reason for an unexpected or negative finding. Any unusual behavior of the subject or inadvertent mistakes by the experimenter are also reported; mistakes on the part of an experimenter have at times opened up new areas of research—but only because the experimenter carefully observed his own behavior as well as that of the subject.

Finally, the entire laboratory report is worded in terms of observable objects or events. Regardless of their complexity, the operations performed and the behavior observed can still be characterized in physical terms. For example, the experimenter who reports that his rat "caught on to the idea that the barpress means reinforcement" has yet to catch on to the idea that nonbehavioral inference in a laboratory report does not.

# A GUIDE TO LABORATORY PROCEDURE AND ANIMAL CARE

The elimination of extraneous stimuli is essential to the success of an experiment. Do not talk loudly, smoke, or leave refuse in the research space. After completing an experiment, replace equipment and discard paper and used food.

Report sick animals and broken apparatus promptly. If you receive a cut or scratch, have it treated immediately.

Handle and pet your rat each day during the first week and as often as is convenient thereafter. Your rat will perform better if he has become accustomed to handling. When picking up the rat, grasp him with the palm of your hand across his back; your fingers should rest on his side and chest. Do not grab the rat by the tail or the scruff of the neck.

When providing water for the rat, use the following procedure. Fill the water bottle and invert it for placement on the cage. Then test the nipple with your finger to ensure that an air bubble is not blocking the flow of water. Exercise care in placing the bottle correctly on the cage and do not displace a water bottle on an adjacent cage. Check the water supply every day; a rat cannot survive for long without water.

One of three procedures will be used to deprive your rat of food or water for experimental purposes. Your instructor will announce which of the procedures will be employed; all are described below.

*Control of food deprivation by percent of* ad libitum *weight.* When you are assigned your rat, determine its weight, after continuous access to food for several days, and enter this value, called the *ad libitum* weight, on the sheet provided in this Manual. The animal's weight must be reduced to "running weight," which is about 85% of his *ad libitum* weight. To do this, remove all food from the cage and provide about one-half maintenance pellet of food a day (less if this procedure fails to reduce the weight in four or five days). After running weight has been achieved, it can be maintained by one to two pellets per day. Before each experiment with your rat, record his weight on the sheet provided and include this datum, as a percent of *ad libitum* weight, in your report. Following each experiment, give the standard daily ration of food to the rat, compensating somewhat for the food consumed in the experiment. For more precise regulation of deprivation, weigh the rat after the experiment and feed him an amount of crumbled food equal to the difference between his running weight and his current weight. Water should be available to the rat at all times.

*Control of food deprivation by feeding rhythm.* When you are assigned your rat, determine its weight and enter this value, called the *ad libitum* weight, on the sheet provided in the Manual. Also record the rat's running weight before each experiment; the ratio of this weight to his *ad libitum* weight should be approximately 85%; in any event, the value should be included in your report. Between experiments, either you or a monitor will maintain your rat's running weight by placing a cup containing crumbled food on your rat's cage for a half-hour daily. Water should be available to the rat at all times.

*Control of water deprivation.* If your laboratory apparatus for operant conditioning includes a water dispenser, deprive your rat of water rather than food. Remove the water bottle from the cage 24 hours before the laboratory period, and replace the bottle after the experiment has been completed. If the rat is to be used on consecutive days, give it access to the water bottle for about an hour after each laboratory period. Food should be available to the rat at all times.

Name ______________________ Lab Hour ______________

Laboratory Instructor ____________ Date ________________

## Animal Weight Sheet

*Ad libitum* weight ______________________________

Running weight (85%) ___________________________

| Date | Weight | Amount Fed | Date | Weight | Amount Fed |
|---|---|---|---|---|---|
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# OPERANT LEVEL AND ACQUISITION OF THE BARPRESS RESPONSE IN THE RAT

The term "operant" refers to a *class* of responses, all of which operate on the environment in some equivalent way. The operant under study in this experiment is the depression of a lever or bar by the white rat. Many responses that differ in form will nevertheless operate the bar. Skinner's research (1938) has shown that if reinforcement is presented after each of these responses, the number of barpresses per minute will increase from the preconditioning rate (the operant level) to a fairly high and stable rate. The present experiment replicates this fundamental demonstration of the control of behavior by its effects on the environment.

## METHOD *

### SUBJECTS

An experimentally naive, adult male albino rat is employed. He has been deprived of food for 23 hours.

### APPARATUS

1. A standard experimental space † is used for operant conditioning of the rat; it includes (a) a grid floor, (b) plexiglass walls, (c) a bar protruding from one wall, (d) an adjacent food tray, and (e) a cue light.

2. A pellet dispenser delivers 45-milligram pellets of food.

3. A cumulative recorder plots the number of barpresses as a function of time.

4. A control box containing switching circuitry enables *E* to present stimuli and reinforcements.

### PROCEDURE

#### ADJUSTING THE EQUIPMENT

1. *E* sets the reinforcement switch to "control" (or "off"), turns on the cumulative recorder, and ensures that the pen is writing.

---

* The details of the method for this and other experiments may vary, depending on the particular subjects and apparatus employed.

† The manufacturer and model of items of equipment in this and subsequent experiments are listed in the Preface.

2. *E* depresses the bar to ensure that each press causes the recorder to advance, and then he resets the recorder.

3. *E* ensures that the food tray is empty, darkens the room, and turns on the cue light.

### DETERMINING THE OPERANT LEVEL

1. *E* places the rat in the box and notes the time. He observes the unreinforced rate of responding (operant level) for ten minutes.

2. Whenever a complete barpress occurs, *E* records the time elapsed since placing the rat in the box. (A complete barpress causes the bar to click and the light to flash on the control box.)

3. *E* notes the form of any barpresses emitted, the parts of the body involved, and how body movements combine to depress the bar.

### CONDITIONING APPROACH TO THE FOOD TRAY

1. When the rat is in the region of the food tray and, preferably, facing it, *E* depresses the reinforcement button, dispensing a pellet. (This also puts a slash mark on the cumulative record.)

2. After the rat has consumed the pellet, *E* repeats Step 1. (If the rat does not pick up the pellet within a few minutes, *E* may crumble a pellet with a moist finger and smear the paste around the food tray.)

3. When the second pellet has been consumed, *E* waits until the rat has left the region of the tray and then dispenses a third pellet.

4. *E* repeats Step 3 about 25 more times, dispensing reinforcement while the rat is in a variety of locations around the experimental space. (Steps 3 and 4 ensure that the rat will not be reinforced for simply crouching over the food magazine.)

5. When the click of the food dispenser causes the rat to approach the tray rapidly, this part of the procedure is completed.

### CONDITIONING BARPRESS

1. *E* changes the reinforcement control to "parallel" and waits for the occurrence of a barpress.

2. If a barpress does not occur in about three minutes, *E* "shapes" the appropriate behavior by reinforcing successive approximations to the final response. *E* first reinforces promptly any movement in the direction of the bar, then movements producing contact of a forepaw with the bar, then depression of the bar, etc. This procedure is continued until an easily observed and readily executed response operates the reinforcing mechanism.

3. *E* also notes the changing form of the barpress response throughout the experimental session. After the rat has emitted twenty reinforced responses, *E* returns the animal to the home cage, turns off the apparatus, and cleans up the research area.

## RESULTS

1. Label the axes of the cumulative record and indicate the units. Add a caption and include the record as Figure 1 of your report.

2. Report the rate of responding during operant level and during continuous reinforcement (CRF). Report the number of reinforcements dispensed during each experimental procedure.

3. If you did not shape the barpress, but simply waited for the occurrence of the operant, what was the time-course of acquisition? In particular, did the time between responses decrease gradually, or did the rat abruptly begin responding at near maximal rate following the first reinforcement?

4. What changes occurred in the topography (form) of the barpress in the course of the experiment? If you shaped the barpress, how were the changes in topography related to the changing requirements for reinforcement?

## DISCUSSION

Consider the following problems when discussing your results.

1. If the sounds of another student's experiment were audible, did the clicks provided by the bar and magazine in that experiment affect your rat? What other examples of lack of environmental control were apparent and what were their effects?

2. What are the variables that controlled and limited the rate of responding during CRF in your experiment? How could you produce a higher rate of barpressing in the rat?

3. While an operant is being acquired, many movements unnecessary for reinforcement are eliminated from the animal's behavior. Some irrelevant movements survive, however, and appear in the final chain of responses that leads to reinforcement. Describe any "superstitious" responses that you observed in the terminal behavior of your rat. How do such responses develop, and why do they survive even though they are not necessary for reinforcement? Discuss the survival of quack remedies that have no valid physiological basis—e.g., hiccough "cures." (See Holland and Skinner, 1961, pp. 89–96.)

## References

Holland, J. G., and Skinner, B. F. *The analysis of behavior.* New York: McGraw-Hill, 1961, pp. 41–106 (esp. p. 78).

Skinner, B. F. *Behavior of organisms.* New York: Appleton-Century, 1938, pp. 48–51, 55–57.

## Evaluation Form

# OPERANT LEVEL AND ACQUISITION OF THE BARPRESS RESPONSE IN THE RAT

(Submit this form with your laboratory report.)

1. The laboratory report required about ______ minutes to complete.

2. At the start of the experiment the rat was at ______ percent of *ad libitum* weight.

3. Approach to the tray required ______ minutes to condition.

4. The barpress response required about ______ minutes to condition.

5. The following malfunctions of the equipment occurred:

6. Other features of the experiment which caused difficulty were:

7. This experiment was conducted in section number ______.

# FORMATION OF A LIGHT-DARK DISCRIMINATION IN THE RAT

All behavior that operates on the environment is to some extent controlled by its stimulus antecedents as well as by its consequences. The analysis and control of operant behavior involves, therefore, a three-term relation: discriminative stimulus, response, reinforcing stimulus ($S^D \rightarrow R \rightarrow S^R$). The previous experiment examined the last two terms of this triad—namely, the effects of presenting a reinforcing stimulus following the emission of an operant. That experiment did not examine the acquisition and maintenance of discriminative control by such stimuli as the bar, the food tray, and the click of the food magazine. In the present experiment, both discriminative and reinforcing stimuli are manipulated in order to establish an operant with high probability of emission under certain stimulus conditions ($S^D$) and low probability of emission under others ($S^\Delta$). This constitutes the formation of a discrimination.

° °

## METHOD

### SUBJECTS

One adult male albino rat is employed. He has a conditioning history of continuous reinforcement for barpressing and has been deprived of food for 23 hours.

### APPARATUS

The apparatus for operant conditioning described in Experiment 1 is used. (The control box is placed so that the rat cannot see the light that flashes during a barpress.) The Manual contains a Data Form for tallying responses in $S^\Delta$.

### PROCEDURE

#### CONDITIONING BARPRESSES IN $S^D$ (S-DEE)

1. *E* turns on the apparatus and ensures that it is working properly. (He checks the cumulative recorder, bar, reinforcement control, and dispenser.)

2. *E* sets the reinforcement control to "parallel," turns on the cue light (the $S^D$), and darkens the room.

3. *E* places the rat in the box.

4. *As soon as* the first barpress produces a reinforcement, *E* simultaneously changes the cue light and the reinforcement control to "off."

### EXTINGUISHING BARPRESSES IN $S^{\Delta}$ (S-DELTA)

1. *E* keeps the cue light off for an $S^{\Delta}$ period of one minute. However, if a response occurs during the last ten seconds of $S^{\Delta}$, the changeover to $S^{D}$ is delayed until ten seconds have elapsed without a response. As a result, a response in $S^{\Delta}$ never immediately precedes the arrival of stimuli that set the occasion for reinforced responses. The presentation of $S^{D}$, then, will not accidentally reinforce responses in $S^{\Delta}$.

2. In the proper Data Form column, *E* keeps a tally of responses made during this and each of the subsequent $S^{\Delta}$ periods.

3. After one minute of $S^{\Delta}$ and as many changeover delays as were required, *E* simultaneously turns on the cue light and turns the reinforcement control to parallel.

4. The procedure is then repeated, beginning with Step 4 above, until barpresses in $S^{D}$ occur with short latency, and barpresses in $S^{\Delta}$ occur only infrequently.

## RESULTS

1. Label the axes of the cumulative record, indicate the units, add a caption, and include the record as Figure 1 of your report.

2. Prepare a graph with the vertical axis labeled "Barpresses per Minute" and the horizontal axis "$S^{\Delta}$ Period." Plot the number of barpresses per minute that occurred in each $S^{\Delta}$ period, as recorded on the Data Form. Connect the points with straight lines and present this function as Figure 2 of your report. Describe the time-course of extinction shown by the data in Figures 1 and 2.

## DISCUSSION

Consider the following problems when discussing your results.

1. Did your rat form a light-dark discrimination? Substantiate your conclusion.

2. What discriminations besides light-dark did you observe in your rat's behavior during this experiment?

3. A change in the values of any of several parameters can affect the formation of a discrimination in this experiment. The difference

in brightness between $S^D$ and $S^\Delta$ is an example of one parameter. List four more.

4. Describe an instance in which human verbal behavior functions as an $S^D$ What is the characteristic response, reinforcement, and $S^\Delta$?

### References

Holland, J. G., and Skinner, B. F. *The analysis of behavior*. New York: McGraw-Hill, 1961, pp. 137–160.

Name ______________________ Lab Hour ______________

Laboratory Instructor ______________ Date ______________

## Data Form

| $S^{\Delta}$ Period | Duration of $S^{\Delta}$ (Seconds) | Tally of Responses in $S^{\Delta}$ | Responses per Minute in $S^{\Delta}$ |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
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Name ______________________ Lab Hour ______________

Laboratory Instructor ______________ Date ______________

## Data Form (continued)

| $S^\Delta$ Period | Duration of $S^\Delta$ (Seconds) | Tally of Responses in $S^\Delta$ | Responses per Minute in $S^\Delta$ |
|---|---|---|---|
| 21 | | | |
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| 23 | | | |
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(continued)

Name ______________________ Lab Hour ______________

Laboratory Instructor ______________ Date ______________

## Data Form (continued)

| $S^{\Delta}$ Period | Duration of $S^{\Delta}$ (Seconds) | Tally of Responses in $S^{\Delta}$ | Responses per Minute in $S^{\Delta}$ |
|---|---|---|---|
| 41 | | | |
| 42 | | | |
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**Evaluation Form**

# FORMATION OF A LIGHT-DARK DISCRIMINATION IN THE RAT

(Submit this form with your laboratory report.)

1. The laboratory report required about ______ minutes to complete.

2. At the start of the experiment the rat was at ______ percent of *ad libitum* weight.

3. The visual discrimination in this experiment required about ______ minutes to establish.

4. The following malfunctions of the equipment occurred:

5. Other features of the experiment which caused difficulty were:

6. This experiment was conducted in section number ______.

# DISCRIMINATIVE CONTROL OF A HOMOGENEOUS RESPONSE CHAIN

An operant response that directly and recurrently produces reinforcement is uncommon. Even when appropriate stimulus conditions prevail, a sequence or *chain* of responses is usually required for reinforcement. A chain of responses produced reinforcements in the last experiment. The components of the chain in that experiment were heterogeneous. The chain began with approach to the bar, proceeded through barpress and approach to the food tray, and ended with the ingestion of the pellet. Heterogeneous chains will be studied in more detail in the next experiment.

The present study is concerned with the discriminative control of a homogeneous chain, a sequence of responses of the same form which leads to reinforcement. The repertoire of your rat established at the end of the last experiment is extended. During successive presentations of $S^D$, the number of barpresses required for each reinforcement is gradually increased until a reasonably long homogeneous chain of responses is established. In order to maintain discriminative control of the chain, an $S^\Delta$ period, during which extinction is in effect, follows each presentation of $S^D$.

## METHOD

### SUBJECTS

One adult male albino rat is employed. He has a history of continuous reinforcement for barpressing in the presence of a light and a history of extinction in the absence of that light. He has been deprived of food for 23 hours.

### APPARATUS

The apparatus for operant conditioning described in Experiment 1 is used. The Manual provides a Data Form for recording the number of reinforced responses in $S^D$ and unreinforced responses in $S^\Delta$.

### PROCEDURE

1. *E* turns on the apparatus and ensures that it is working properly.

2. *E* sets the reinforcement control to "series," turns on the cue light, and darkens the room.

3. *E* places the rat in the box, depresses the reinforcement button, and holds it down. The first barpress then produces reinforcement.

4. *E* keeps the button depressed until four additional reinforcements are delivered on CRF (continuous reinforcement) during $S^D$.

5. When the fifth reinforcement is delivered, *E* releases the button and turns off the cue light for an $S^\Delta$ period of one minute. However, if a response occurs during the last ten seconds of $S^\Delta$, the changeover to $S^D$ is delayed until ten seconds have elapsed without a response occurring.

6. *E* keeps a tally, on the Data Form included in this Manual, of the number of responses during each $S^D$ and $S^\Delta$ period.

7. After at least one minute of $S^\Delta$ and as many changeover delays as were required, *E* turns on the cue light. During this $S^D$ period, every *other* response is reinforced, for a total of five reinforcements.

8. The procedure is then repeated, beginning with step 5. *E* gradually steps up the number of responses required for reinforcement, setting a new criterion for each new $S^D$ period. The requirement is constant, however, for the five reinforcements *within* each $S^D$ period. *E* may occasionally depart from the preset criterion in order to deliver reinforcement after a burst of responses and not after a response preceded by a pause.

9. The ratio of responses to reinforcements is advanced only as long as pausing does not develop. When pausing occurs, *E* maintains the value of the ratio for a few $S^D$ periods or sometimes reduces it. The object is to establish a stable chain of responses which is as long as practical within the time limit of the experimental session. Toward the end of the session, *E* selects a final value of the ratio and administers about twenty reinforcements on this fixed-ratio schedule. On the Data Form provided, he records the changing ratio requirements throughout the session.

## RESULTS

1. Include the cumulative record as Figure 1 of your report. Indicate above the record the ratio requirement in effect during each segment.

2. Plot the number of responses per minute emitted in each $S^\Delta$ period as a function of successive periods and include this as Figure 2 of your report.

3. Describe the time-course of acquisition of the chain, the points at which excessive pausing occurred, and the effect of intermittent reinforcement during $S^D$ on the rate of responding during $S^\Delta$.

## DISCUSSION

Consider the following problems when discussing your results.

1. Stable performance on a fixed-ratio schedule is characterized by a pause after reinforcement, followed by a high rate of responding until the next reinforcement. Account for this response pattern by examining the relation at each moment between responding and reinforcement during the interval between reinforcements. Start by noting that a response immediately preceded by reinforcement is never itself reinforced. (For an analysis of the control of behavior by fixed-ratio schedules of reinforcement, see Ferster and Skinner, 1957.)

2. How could you eliminate the fixed-ratio pause and still maintain high rates of responding?

3. When an operant is conditioned on a fixed-ratio schedule of reinforcement, it is sometimes wisest not to reinforce a response preceded by a pause, even if that response completes the requirement for reinforcement. Why? This procedure, which involves keeping reinforcement available for only a limited period, is called "limited hold." Describe some behavior outside the laboratory which is maintained by reinforcement with a limited hold—e.g., catching a bus.

### References

Ferster, C. B., and Skinner, B. F. *Schedules of reinforcement.* New York: Appleton-Century-Crofts, 1957. Chap. 4.

Holland, J. G., and Skinner, B. F. *The analysis of behavior.* New York: McGraw-Hill, 1961, pp. 117–136.

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Calcutta
25/3, B. C. Road

Name ______________________ Lab Hour ______________

Laboratory Instructor ______________ Date ______________

## Data Form

| $S^D$ Period | Ratio Requirement | Duration of $S^\Delta$ (Seconds) | Tally of Responses in $S^\Delta$ | Responses per Minute in $S^\Delta$ |
|---|---|---|---|---|
| 1 | | | | |
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Name ______________________ Lab Hour ______________________
Laboratory Instructor ______________ Date ______________________

## Data Form (continued)

| $S^D$ Period | Ratio Requirement | Duration of $S^\Delta$ (Seconds) | Tally of Responses in $S^\Delta$ | Responses per Minute in $S^\Delta$ |
|---|---|---|---|---|
| 21 | | | | |
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(continued)

Name ______________________ Lab Hour ______________

Laboratory Instructor ____________ Date ________________

## Data Form (continued)

| $S^D$ Periods | Ratio Requirement | Duration of $S^\Delta$ (Seconds) | Tally of Responses in $S^\Delta$ | Responses per Minute in $S^\Delta$ |
|---|---|---|---|---|
| 41 | | | | |
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**Evaluation Form**

# DISCRIMINATIVE CONTROL OF A HOMOGENEOUS RESPONSE CHAIN

(Submit this form with your laboratory report.)

1. The laboratory report required about _______ minutes to complete.

2. At the start of the experiment, the rat was at _______ percent of *ad libitum* weight.

3. A stable chain of _______ responses per reinforcement required _______ reinforcements and about _______ minutes to condition.

4. The following malfunctions of the equipment occurred:

5. Other features of the experiment which caused difficulty were:

6. This experiment was conducted in section number _______.

Experiment 4

# THE ROLE OF SECONDARY REINFORCEMENT IN THE FORMATION AND MAINTENANCE OF A HETEROGENEOUS RESPONSE CHAIN

As described earlier, the control of operant behavior has three components: $S^D \rightarrow R \rightarrow S^R$. Each component can be manufactured in the laboratory. In Experiment 1, an arbitrary response (R) was established as an operant by selective reinforcement. In Experiment 2, an arbitrary stimulus was established as the prerequisite condition ($S^D$) for the emission of the response. In this experiment, an arbitrary stimulus is established as the requisite condition for shaping and maintaining the response—that is, the stimulus is established as a secondary reinforcer ($S^r$).

Research of Kelleher and Gollub (1962) has shown that an arbitrary stimulus will function as a reinforcer, strengthening the behavior that precedes it, if it is first established as a discriminative stimulus, setting the occasion for responses that follow it. Therefore, the $S^D$ for the barpress response, which was established in the preceding experiments, may be used in this experiment as an $S^r$ to condition and maintain another response with a different topography, pushing a rod. The cue light, then, has a dual function in the heterogeneous chain of responses:

$$R_1 \text{ (Rodpush)} \rightarrow S^{r \cdot D} \text{ (Cue light)} \rightarrow R_2 \text{ (Barpress)} \rightarrow S^R \text{ (Food)}.$$

The reinforcing properties of the discriminative stimulus are explored in four ways. First, the rodpush is shaped and maintained by means of the cue light. Second, the rodpush is partially extinguished when the cue light is no longer presented after occurrences of the response. Third, the rodpush is reconditioned when the cue light is reintroduced after each response, although food reinforcement is no longer presented at the end of the chain. Finally, the effect of the preceding reconditioning of rodpush, achieved exclusively with the secondary reinforcer, is assessed by observing the frequency of responding in a second period of extinction.

## METHOD

### SUBJECTS

One adult male albino rat is employed. He has a history of fixed-ratio reinforcement for barpressing in the presence of a light and a history of extinction in the absence of that light. He has been deprived of food for 23 hours.

## APPARATUS

The apparatus for operant conditioning described in Experiment 1 is used. In addition, a microswitch is mounted on the roof of the box; its actuating arm (here called the "rod") projects downward into the space, terminating 3 inches above the floor. A force of 15 grams or greater, applied in a horizontal direction, closes the microswitch. For this experiment, the rod is wired to activate the cumulative recorder, and the bar is wired to the reinforcing mechanism.

## PROCEDURE

1. *E* turns on the apparatus and ensures that it is working properly.

2. *E* sets the reinforcement control to "series," turns on the cue light, and darkens the room.

3. *E* places the rat in the box and reinforces barpresses on a fixed-ratio (FR) schedule that requires about 20% fewer responses than the one employed at the end of the preceding experiment.

4. After one reinforcement, *E* turns off the cue light and follows the $S^\Delta$ procedure employed previously (one minute, including a ten-second changeover delay.)

5. *E* repeats this alternation of $S^D$ and $S^\Delta$ six times, or until $S^\Delta$ responding is infrequent. ($S^\Delta$ responses may be tallied on the Data Form provided.)

6. After completing Step 5, *E* begins to shape the rodpush in the next $S^\Delta$ period. When the rat moves in the direction of the rod or contacts it, *E* immediately turns on the cue light, initiating a period of $S^D$. One reinforcement is then dispensed to the rat on the FR schedule.

7. During subsequent $S^\Delta$ periods, *E* reinforces successive approximations to rodpush by presenting the $S^D$. However, *E* avoids presenting the $S^D$ following a barpress in $S^\Delta$ during the conditioning of the chain.

8. When the rodpush is conditioned, *E* continues to reinforce the entire chain of responses until the latencies of rodpush and barpress are short and pausing is infrequent.

9. *E* partially extinguishes rodpush by keeping the light off until the rate of responding falls to a relatively low value. Neither rod-

push nor barpress is reinforced. (Extinction responses in successive time intervals may be tallied in the corresponding rows of the Data Form provided.)

10. *E* reintroduces secondary reinforcement by presenting the cue light following a rodpush response. The cue light is the $S^D$ for barpressing; after the rat emits the required number of barpresses, *E* turns off the light but does *not* dispense a pellet. The entire step is repeated four more times.

11. *E* initiates a second period of extinction, in which the cue light again remains off and neither rodpush nor barpress is reinforced.

12. *E* repeats Steps 10 and 11 until he, the rat, or the allotted time is exhausted.

## RESULTS

1. Include the cumulative record of rodpushing as Figure 1 in your report. Identify the procedure employed during each segment.

2. Describe the changes in the topography of rodpush that took place during shaping.

3. Describe the rate of emission and topography of rodpushing when this response no longer produced the discriminative stimulus for barpressing.

4. Describe the rate of emission and topography of rodpushing after secondary reinforcement of this response had been reintroduced and then discontinued again. Contrast the properties of responding during the two extinction periods.

## DISCUSSION

Consider the following problems when discussing your results.

1. What evidence do your findings provide concerning the empirical generalization that discriminative stimuli are also secondary reinforcers?

2. Examine a common chain in human behavior (e.g., making a telephone call) and diagram the component stimuli and responses, as illustrated in the introduction to this experiment.

3. Describe the changes that take place in an overt chain of verbal responses as it becomes covert with practice—for example, performing simple arithmetic or reading in a newly acquired language. What are the component responses, $S^D$s and $S^r$s, in the chain when it is overt? When it is covert? What is the basis for your inference in the latter case? (For a discussion of covert chains, see Keller and Schoenfeld, 1950.)

## References

Holland, J. G., and Skinner, B. F. *The analysis of behavior.* New York: McGraw-Hill, 1961, pp. 161–180.

Kelleher, R. T., and Gollub, L. R. A review of positive conditioned reinforcement. *Journal of the experimental analysis of behavior,* 1962, 5, 543–597.

Keller, F. S., and Schoenfeld, W. N. *Principles of psychology.* New York: Appleton-Century-Crofts, 1950.

Name ______________________ Lab Hour ______________

Laboratory Instructor ____________ Date ________________

## Data Form

| $S^{\Delta}$ | Barpress Responses | Rodpush Responses | Extinction I | Tally of Rodpush Responses in Extinction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | — | a | | | | | | | | | |
| 2 | | — | b | | | | | | | | | |
| 3 | | — | c | | | | | | | | | |
| 4 | | — | d | | | | | | | | | |
| 5 | | — | e | | | | | | | | | |
| 6 | | — | f | | | | | | | | | |
| 7 | | | g | | | | | | | | | |
| 8 | | | h | | | | | | | | | |
| 9 | | | i | | | | | | | | | |
| 10 | | | j | | | | | | | | | |
| 11 | | | Reconditioning | | | | | | | | | |
| 12 | | | 1 | | | | | | | | | |
| 13 | | | 2 | | | | | | | | | |
| 14 | | | 3 | | | | | | | | | |
| 15 | | | 4 | | | | | | | | | |
| 16 | | | 5 | | | | | | | | | |
| 17 | | | Extinction II | | | | | | | | | |
| 18 | | | a | | | | | | | | | |
| 19 | | | b | | | | | | | | | |
| 20 | | | c | | | | | | | | | |
| 21 | | | d | | | | | | | | | |
| 22 | | | e | | | | | | | | | |
| 23 | | | f | | | | | | | | | |
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| 25 | | | h | | | | | | | | | |

**Evaluation Form**

# THE ROLE OF SECONDARY REINFORCEMENT IN THE FORMATION AND MAINTENANCE OF A HETEROGENEOUS RESPONSE CHAIN

(Submit this form with your laboratory report.)

1. The laboratory report required about ______ minutes to complete.

2. At the start of the experiment the rat was at ______ percent of *ad libitum* weight.

3. The experiment required about ______ minutes to complete.

4. The following malfunctions of the equipment occurred:

5. Other features of the experiment which caused difficulty were:

6. This experiment was conducted in section number ______

## Experiment 5

# CHAINING IN HUMAN VERBAL BEHAVIOR

Nowhere are chains of responses found with such heterogeneity, fine articulation, and speed of execution as in human verbal behavior. These "intraverbal" chains display, moreover, a remarkable range in length, from "Howareya" on the one hand to The Lord's Prayer on the other. Every response in an intraverbal chain produces an (auditory) $S^D$ for the responses that follow and an $S^r$ for those that precede. The speaker who is interrupted in the midst of a memorized address and must "get a running start"—that is, marshal cues from earlier responses in the chain—illustrates that each response is under the discriminative control of several preceding responses, not just the last one.

The discriminative control exerted over the next verbal response increases as more and more verbal responses precede it. For example, tell several speakers the first word of a sentence and ask them to guess the second word; responses will be diverse. Tell these same speakers an initial two words, and the variety of responses will decrease. In general, as a greater number of preceding words (discriminative stimuli) are presented, the variety of responses will decrease—or, equivalently, the probability of a particular response will increase.

The present study is an elaboration of this simple design; it requires a subject to recall and to reconstruct sequences of words. In this way, the experiment determines how the probability of a verbal response is affected when the number of preceding verbal stimuli that control the response is varied.

## METHOD

### SUBJECTS

The members of the laboratory serve as Ss. The section is divided into two groups (I and II); each group prepares the materials for testing the other group. The instructor performs the steps of the procedure assigned to *E*. If the laboratory section contains fewer than eight students, each student brings in a subject.

### APPARATUS

All the required materials are provided in this Manual (pp. 55–75).

1. Four forms are supplied for generating order approximations to English. Each of the order approximations is a list of thirty words, prepared so that the selection of each word is determined by a

constant number of preceding words. In a fifth-order approximation, for example, every word is partially determined by each of the four preceding words. Forms are included for generating second-, third-, fourth-, and fifth-order approximations. Completed forms contain zero- and first-order approximations, and passages of English text.*

2. Seven forms are supplied for the Ss' recall of order approximations; each form corresponds to one of the seven order approximations listed above.

3. Two forms are supplied for testing and scoring Ss' reconstruction of order approximations: one form contains seven order approximations to English, with every fifth word deleted (Test Form), and the other contains the deleted words (Answer Form).

4. Two Data Forms are supplied for recording the number of words correctly recalled and reconstructed by Ss in one of the groups.

## PROCEDURE

### GENERATING ORDER APPROXIMATIONS TO ENGLISH

1. On a table in front of each group, *E* spreads out the four forms for generating order approximations. The forms for the second- and fourth-order approximations are taken from one copy of the Manual; those for the third- and fifth-order approximations, from another copy. In this way, both sides of a page are never used.

2. The first S looks at one of the forms and reads the sequence of words to himself. He composes a sentence containing this sequence of words and, in the next space on the form, prints the word he used directly after the sequence.

3. *S* takes a piece of paper and covers the top of the form so that the first word in the sequence that he viewed cannot be seen. (In this way, the next *S* will see the same number of words when generating his response.)

4. S repeats this procedure with each of the remaining forms. Meanwhile, a second *S* begins his progression through the series of forms—reading, generating, covering, as described above. All members of the group proceed, in turn, through the series of forms, as many times as necessary until the four order approximations are completely generated.

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* The words in a zero-order approximation are selected at random from a dictionary; those in a first-order approximation are selected at random from prose passages, thereby preserving their relative frequencies of occurrence in English. The order approximations presented in this Manual are, with one exception, those reported by Miller and Selfridge (1950).

### TESTING THE RECALL OF ORDER APPROXIMATIONS

1. *E* takes the forms generated by group I and reads them to group II. He reads each thirty-word chain aloud, slowly and without inflection. After he completes *each* passage, the Ss are given 90 seconds in which to write down, on the Test Form provided, as many of the words as they can recall. Using a randomized sequence that he does not reveal at this time, *E* repeats this procedure for all seven order approximations, including the three provided for group II in this Manual.

2. *E* repeats the preceding step, with group I now serving as Ss. He reads the three order approximations provided for this group in the Manual and the four order approximations generated by group II. Again, an arbitrary and concealed order is employed.

### TESTING AND SCORING THE RECONSTRUCTION OF ORDER APPROXIMATIONS

1. While *E* reads the order approximations to group II each S in group I attempts to fill in the words that have been deleted from the Reconstruction Test Form provided in the Manual. The Ss in group I then exchange these forms and score them by referring to the accompanying Answer Form, which contains the deleted words. (The score for each reconstructed order approximation is the number of words correctly filled in.)

2. Conversely, while *E* reads the order approximations to group I, group II completes and scores the Reconstruction Test Forms.

### SCORING THE RECALL OF ORDER APPROXIMATIONS

1. *E* divulges the sequence in which he read the order approximations to each group, and these are entered on each Recall Test Form.

2. The Ss within each group exchange Recall Test Forms with each other.

3. *E* reads aloud the four order approximations generated by group I, and the Ss in group II score the Recall Test Forms accordingly. The score for each form is the number of words correctly recalled, whether or not in the correct sequence.

4. As *E* reads each order approximation, the Ss in group I transcribe the words onto the appropriate Generating Forms in the Manual. (This provides each S with a record of the order approximations that correspond to the recall data that he will be reporting.)

5. Conversely, while *E* reads the four order approximations generated by group II, the Ss in group I score their Recall Test Forms,

and the Ss in group II transcribe the words onto the appropriate Generating Forms.

6. Now the Ss in each group score their Recall Test Forms for the zero-order approximation, the first-order approximation, and the English text. This is done by referring to the Completed Generating Forms provided for their group in the Manual.

7. The scores obtained by each S in the reconstruction and recall of order approximations are displayed on the blackboard for the two groups separately. Using the Data Forms provided in this Manual, each S in group I transcribes the scores from group II, and conversely.

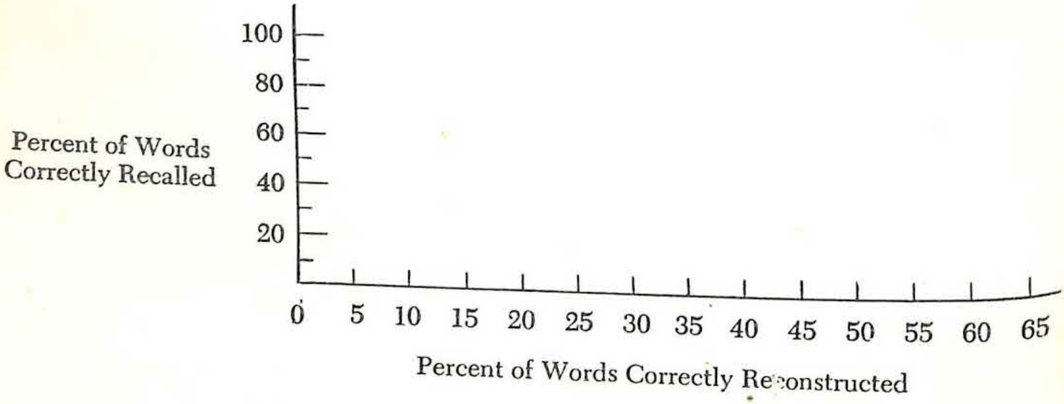
## RESULTS

1. Present a bar graph showing the percent of words correctly recalled as a function of the order of approximation to English.

2. Present a bar graph showing the percent of words correctly reconstructed as a function of the order of approximation to English.

3. Describe and contrast the form of these functions. State at what point, if any, the probability of a particular response in a chain was no longer increased by adding preceding verbal stimuli.

4. Plot the percent of words correctly recalled against the percent correctly reconstructed. The two scores for each order approximation provide one point. A total of seven points will then appear in coordinates like those shown below. If these behavioral measures both reflect the amount of intraverbal control in a chain, then the corresponding graph of your data should reveal a systematic relation between them. Compare the orderliness of the three obtained functions that relate recall, reconstruction, and order approximation to each other.



## DISCUSSION

Consider the following problems when discussing your results.

1. (Optional) How do your results compare with those reported by Miller and Selfridge (1950) and by Salzinger et al. (1962)?

2. Are order approximation and recall (or reconstruction accuracy) related in the same ways according to the averaged group data as they are according to the data for individual Ss, considered singly?

3. It has been contended that learning to utter grammatical sentences in a foreign language consists of learning certain recurrent intraverbal chains in the language. How can this contention be reconciled with the observation that a speaker who is fluent in the language can generate new but grammatical sentences? (For a discussion of intraverbal chains and bilingualism, see Skinner, 1957.)

### References

Miller, G. A., and Selfridge, Jennifer. Verbal context and the recall of meaningful material. *American journal of psychology*, 1950, *63*, 176–185. Bobbs-Merrill reprint P-242.

Salzinger, K., Portney, Stephanie, and Feldman, R. The effect of order approximation to the statistical structure of English on the emission of verbal responses. *Journal of experimental psychology*, 1962, *64*, 52–57.

Skinner, B. F. *Verbal behavior*. New York: Appleton-Century-Crofts, 1957, pp. 71–80.

# THIRD-ORDER APPROXIMATION TO ENGLISH

## Generating Form

**1. happened**

**2. to**

**3.**

**4.**

**5.**

**6.**

**7.**

**8.**

**9.**

**10.**

**11.**

**12.**

**13.**

**14.**

**15.**

**16.**

**17.**

**18.**

**19.**

**20.**

**21.**

**22.**

**23.**

**24.**

**25.**

**26.**

**27.**

**28.**

**29.**

**30.**

**(Look at the 2 prior words and PRINT the next word in the sentence.)**

## FOURTH-ORDER APPROXIMATION TO ENGLISH

Generating Form

1. the
2. first
3. list
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.

(Look at the 3 prior words and PRINT the next word in the sentence.)

## FIFTH-ORDER APPROXIMATION TO ENGLISH

### Generating Form

1. go
2. it
3. will
4. be
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.

(Look at the 4 prior words and PRINT the next word in the sentence.)

## Completed Generating Form for Group I

### ZERO-ORDER APPROXIMATION TO ENGLISH

1. crane
2. therewith
3. egg
4. journey
5. applied
6. crept
7. burnish
8. pound
9. precipice
10. king
11. eat
12. sinister
13. descend
14. cab
15. Idaho
16. baron
17. alcohol
18. inequality
19. Illinois
20. benefactor
21. forget
22. lethargy
23. fluted
24. watchtower
25. attendance
26. obeisance
27. cordiality
28. dip
29. prolong
30. bedraggle

## Completed Generating Form for Group II

### ZERO-ORDER APPROXIMATION TO ENGLISH

1. byway
2. consequence
3. handsomely
4. financier
5. bent
6. flux
7. cavalry
8. swiftness
9. weatherbeaten
10. extent
11. betwixt
12. trumpeter
13. pebbly
14. complication
15. vigorous
16. tipple
17. careen
18. obscure
19. attractive
20. consequence
21. expedition
22. pane
23. unpunished
24. prominence
25. chest
26. sweetly
27. basin
28. awoke
29. photographer
30. ungrateful

## Completed Generating Form for Group I

### FIRST-ORDER APPROXIMATION TO ENGLISH

1. house
2. reins
3. women
4. brought
5. screaming
6. especially
7. much
8. was
9. said
10. cake
11. love
12. that
13. school
14. to
15. a
16. they
17. in
18. is
19. the
20. home
21. think
22. with
23. are
24. his
25. before
26. want
27. square
28. of
29. the
30. wants

## Completed Generating Form for Group II

## FIRST-ORDER APPROXIMATION TO ENGLISH

1. abilities
2. with
3. that
4. beside
5. I
6. for
7. waltz
8. you
9. the
10. sewing
11. tea
12. realizing
13. most
14. so
15. the
16. together
17. home
18. and
19. for
20. were
21. wanted
22. to
23. concert
24. I
25. posted
26. he
27. her
28. it
29. the
30. walked

## Completed Generating Form for Group I

### ENGLISH TEXT

1. Archimedes
2. was
3. a
4. lonely
5. sort
6. of
7. eagle
8. as
9. a
10. young
11. man
12. he
13. had
14. studied
15. for
16. a
17. short
18. time
19. at
20. Alexandria
21. Egypt
22. where
23. he
24. made
25. a
26. life-long
27. friend
28. a
29. gifted
30. mathematician

## Completed Generating Form for Group II

### ENGLISH TEXT

1. for
2. centuries
3. the
4. brain
5. has
6. been
7. a
8. challenging
9. puzzle
10. for
11. scientists
12. in
13. many
14. fields
15. they
16. have
17. described
18. much
19. of
20. the
21. structure
22. of
23. the
24. brain
25. but
26. its
27. functions
28. are
29. poorly
30. understood

## Recall Test Form A

______ ORDER APPROXIMATION

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.

## Recall Test Form B

______ ORDER APPROXIMATION

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.

## Recall Test Form C

### ______ ORDER APPROXIMATION

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.

## Recall Test Form D

## ______ ORDER APPROXIMATION

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.

## Recall Test Form E

______ ORDER APPROXIMATION

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.

## Recall Test Form F

______ ORDER APPROXIMATION

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.

Recall Test Form G

______ ORDER APPROXIMATION

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

12.

13.

14.

15.

16.

17.

18.

19.

20.

21.

22.

23.

24.

25

26.

27.

28.

29.

30.

Name ________________ Lab Hour ________________

Laboratory Instructor ____________ Date ________________

## Reconstruction Test Form

### A. ______ Order Approximation

hammer neatly unearned ill-treat ________ turkey that valve outpost ________ isolation solemnity lurk far-sighted ________ latitude task pub excessively ________ competence doubtless tether backward ________ exponent prose resourcefulness intermittently ________ Hawaii inhabit topsail nestle ________ liner communist Canada debauchery ________ appraise mirage loop referendum ________ absolutely towering aqueous lunatic ________

### B. ______ Order Approximation

came from the beginning ________ end this here is ________ top spins in a ________ by the library is ________ of happiness and love ________ very nice of her ________ fell from the window ________ went home from work ________ pass the cigarettes down ________ earth he picked an ________

### C. ______ Order Approximation

especially is eat objections ________ covering seemed the family ________ that substance dinner raining ________ black the see for ________ passionately and so I ________ is window to down ________ to boy appearance think ________ again room the beat ________ in there beside some ________ was after women dinner ________

### D. ______ Order Approximation

house to ask for ________ to earn our living ________ working towards a goal ________ his team in old ________ was a wonderful place ________ it even pleasant to ________ about and laugh hard ________ he tells lies he ________ not tell me the ________ why you are is ________

### E. ________ Order Approximation

the next room to __________ silver in Pennsylvania is __________ in getting home on __________ my date was tremendous __________ going there skiing this __________ would end and have __________ more objections to his __________ on the radio last __________ played the viola in __________ orchestra and chorus performed __________

### F. ________ Order Approximation

you come through my __________ is that game since __________ lives in school is __________ and wanted help call __________ well and substance was __________ piano is a mistake __________ this is warm glow __________ and girl went to _______ ___ four turtledoves in my __________ is fine appearance of __________

### G. ________ Order Approximation

the old professor's seventieth __________ was made a great __________ for public honors and __________ gathering of his disciples __________ former pupils from all __________ Europe thereafter he lectured __________ less and less often __________ for ten years received __________ few of his students __________ his house near the __________

## Reconstruction Answer Form

### A. Zero-Order Approximation

| | | | | |
|---|---|---|---|---|
| earldom | broaden | Britain | chafe | query |
| auburn | raisin | engulf | dowager | problem |

### B. Third-Order Approximation

| | | | | |
|---|---|---|---|---|
| and | the | house | full | is |
| that | she | to | to | apple |

### C. First-Order Approximation

| | | | | |
|---|---|---|---|---|
| are | I | into | will | after |
| hold | with | go | is | chorus |

### D. Fifth-Order Approximation

| | | | | |
|---|---|---|---|---|
| is | by | for | New York | wasn't |
| talk | when | should | reason | evident |

### E. Fourth-Order Approximation

| | | | | |
|---|---|---|---|---|
| mine | late | time | fun | day |
| no | speech | night | the | the |

### F. Second-Order Approximation

| | | | | |
|---|---|---|---|---|
| appetite | he | jumping | him | a |
| on | in | write | book | the |

### G. Text

| | | | | |
|---|---|---|---|---|
| birthday | occasion | a | and | over |
| publicly | and | a | at | university |

Name ______________________ Lab Hour ______________

Laboratory Instructor ______________ Date ______________

## Data Form for Test of Recall

(Number of Words Recalled from a List of Thirty Words)

Order Approximation

| Subject | 0 | 1 | 2 | 3 | 4 | 5 | Text |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |
| 9 | | | | | | | |
| 10 | | | | | | | |
| 11 | | | | | | | |
| 12 | | | | | | | |
| Sum | | | | | | | |
| Average | | | | | | | |
| % Correct | | | | | | | |

Name ______________________________ Lab Hour ____________________

Laboratory Instructor ______________ Date ________________________

## Data Form for Test of Reconstruction

(Number of Words Correctly Replacing Ten Deleted Words)

Order Approximation

| Subject | 0 | 1 | 2 | 3 | 4 | 5 | Text |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |
| 9 | | | | | | | |
| 10 | | | | | | | |
| 11 | | | | | | | |
| 12 | | | | | | | |
| Sum | | | | | | | |
| Average | | | | | | | |
| % Correct | | | | | | | |

## Evaluation Form

# CHAINING IN HUMAN VERBAL BEHAVIOR

(Submit this form with your laboratory report.)

1. The laboratory report required about ______ minutes to complete.

2. The experiment required about ______ minutes to complete.

3. Features of the experiment which caused difficulty were:

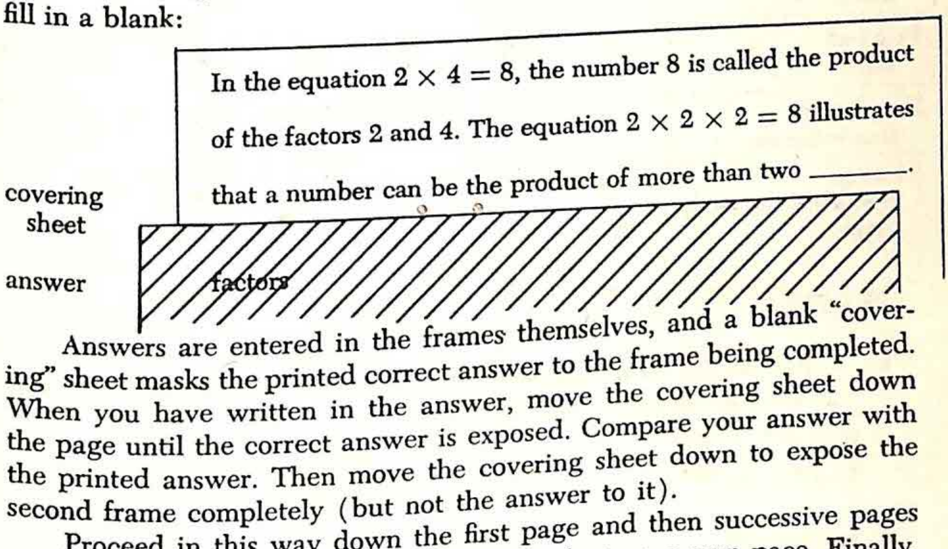
4. This experiment was conducted in section number ______.

# A PROGRAMMED INTRODUCTION TO COMMON LOGARITHMS AND DECIBELS

## INSTRUCTIONS

The three experiments that follow this program use the decibel as a unit of measurement. The program is designed to teach you the basic operations performed with logarithms and decibels if you do not already know them. If you score less than 18 points (90%) on the pre-test, complete the program.

The program consists of a series of "frames" like that shown below. Each frame requires you to read some text and to answer a question or fill in a blank:



In the equation $2 \times 4 = 8$, the number 8 is called the product of the factors 2 and 4. The equation $2 \times 2 \times 2 = 8$ illustrates that a number can be the product of more than two ______.

Answers are entered in the frames themselves, and a blank "covering" sheet masks the printed correct answer to the frame being completed. When you have written in the answer, move the covering sheet down the page until the correct answer is exposed. Compare your answer with the printed answer. Then move the covering sheet down to expose the second frame completely (but not the answer to it).

Proceed in this way down the first page and then successive pages until you have completed all 68 frames; work at your own pace. Finally, complete and score the post-test to assess how much you have learned.

The program has been tested and revised repeatedly. More than 400 students have completed the program during its development. The table below reports data on the final (published) version of the program for the last seven subjects tested. None of these subjects had had advanced mathematics.

| Subject | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Age | 16 | 18 | 19 | 20 | 22 | 22 | 27 |
| Sex | M | F | F | M | F | M | F |
| Academic level | High school | Sophomore | Sophomore | Senior | Senior | Graduate student | Senior |
| Major field | —— | Language | Nursing | English | German | Design | German |
| Grade-point average (4 = A, 3 = B, 2 = C) | —— | 3.4 | 2.8 | 2.2 | 2.7 | 2.5 | 2.6 |
| High school algebra and geometry? | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Pre-test score (%) | 50 | 10 | 10 | 0 | 15 | 25 | 5 |
| Post-test score (%) | 100 | 100 | 90 | 100 | 90 | 90 | 68 |
| Number of frame errors | 4 | 0 | 6 | 5 | 8 | 2 | 11 |
| Time to complete program (min.) | 50 | 60 | 70 | 65 | 60 | 75 | 80 |

## PRE-TEST

1. "2.76 is the common logarithm of 580." Circle all the equations below that are equivalent to this statement.

   a. $2.76^{10} = 580$
   c. $\log 2.76 = 580$
   b. $10^{2.76} = 580$
   d. $\log 580 = 2.76$

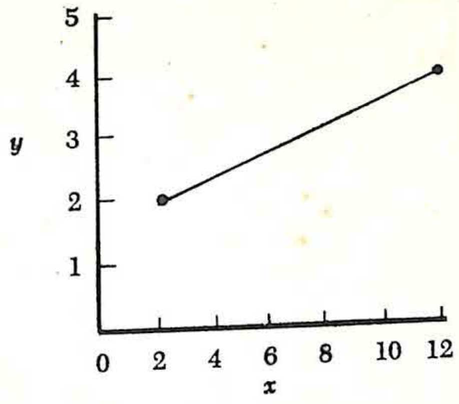
2. $\log 2 = .30$
   $\log 3 = .48$
   $\log 5 = .70$
   $\log 7 \doteq .85$
   $\log 9 = .95$

   Calculate:
   a. $\log 21$
   b. $\log (7/5)$
   c. $\log (1/3)$
   d. $\log 9^5$

3. A very soft whisper has a sound pressure approximately ten times the threshold of hearing. How many decibels (SPL) is this sound pressure?

4. For the function shown,

   slope = Δ ____ / Δ ____ = ______



5. Circle any equations below that do NOT represent straight-line functions.

   a. $y = x^2$

   b. $y = 14x$

   c. $\Delta y/\Delta x = -.37$

   d. $\Delta y = (1/3)\Delta x$

6. By displaying the results of an experiment in a graph, a psychologist wishes to test the hypothesis that the relation between two variables, $x$ and $y$, is given by a function of the following form: $y = x^n$, where $n$ is some unknown constant.

   a. What kind of measurement unit should be used for expressing $x$ and $y$ on the axes of the graph?

   b. If the relation has the hypothesized form, what will the graph of the function look like?

   c. If the relation has the hypothesized form, how would the unknown power $n$ be determined from the graph?

## ANSWERS TO PRE-TEST

| | *Points* |
|---|---|
| 1. b, d | 2 |
| 2. a. 1.33 | 1 |
| b. .15 | 1 |
| c. –.48 | 1 |
| d. 4.75 | 1 |
| 3. 20 db | 3 |
| 4. $\Delta y/\Delta x = 1/5$ | 3 |
| 5. a | 2 |
| 6. a. decibels (or any logarithmic units) | 2 |
| b. The function will be a straight line. | 2 |
| c. The slope of the function will equal $n$. | 2 |
| Total | 20 |

# THE PROGRAM

## POWERS AND LOGARITHMS

1. In the equation $2 \times 3 = 6$, the number 6 is called the product of the factors 2 and 3. In the equation $2 \times 2 \times 2 = 8$, the number 2 appears ____ times as a factor.

3

2. The expression $2 \times 2 \times 2$ may be abbreviated as $2^3$. In this abbreviated form, ____ represents the number of times that ____ appears as a factor.

3
2

3. In the abbreviated notation, $2^3$, 3 is called the *power* to which 2 is raised. In the expression $4^7$, the number 4 is raised to the ____ power.

seventh

4. $10{,}000 = 10 \times 10 \times 10 \times 10 = 10^{\_\_}$. In this abbreviated notation, the number 10 is raised to the ____ power.

$10^4$
fourth

5. Powers have important mathematical properties.
$2^3 \times 2^5 = 2{\times}2{\times}2 \times 2{\times}2{\times}2{\times}2{\times}2 = 2^{\_\_}$
$7^1 \times 7^3 \times 7^2 = 7 \times 7{\times}7{\times}7 \times 7{\times}7 = 7^{\_\_}$
$23^7 \times 23^5 = 23^{\_\_}$

$2^8$
$7^6$
$23^{12}$

6. The general product rule illustrated by these examples may be stated as follows: The power of a product equals the ____ of the powers of the separate factors.

sum

7. Other multiplication problems may be solved by converting each factor into the power notation and using the product rule:

$16 \times 8 \times 4 = 2^4 \times 2^{\_\_} \times 2^{\_\_} = 2^{\_\_}$

$2^4 \times 2^3 \times 2^2 = 2^9$

8. $9 \times 27 = 3^2 \times 3^{\_\_} = 3^{\_\_}$

$3^2 \times 3^3 = 3^5$

9. Any multiplication problem may be solved by the product rule if each factor is first expressed as a power of the same basic number. Tables are available for converting all numbers to powers of a basic number and back again. What was the basic number employed in the previous frame? ____

3

10. The tables usually employed for this purpose use the basic number 10 and are called tables of common logarithms. A *common logarithm* of a number is the power to which 10 must be raised in order to equal the number.

Since $100 = 10^{②}$

the common logarithm of 100 is ②

Circle the common logarithm of 1,000 in the list below.

a. $10^3$ b. $3 \times 10$ c. 3 d. $3^{10}$ e. 10

c. 3

11. In mathematical notation the phrase "3 is the common logarithm of 1,000" would be written as: log 1,000 = 3. Rewrite the following in mathematical logarithm notation:

a. The common logarithm of 100 is 2.
b. $10{,}000 = 10^4$
c. $M = 10^a$

a. $\log 100 = 2$
b. $\log 10{,}000 = 4$
c. $\log M = a$

12. $\log A = 4$

$A = 10^{\_\_} = \_\_\_\_$

$10^4 = 10{,}000$

13. Since $10^a \times 10^b = 10^{a+b}$, the product rule can be expressed in logarithm form.

$$\log (a \times b) = \log \_\_\_ + \log \_\_\_$$

---

log a + log **b**

---

14. The logarithm of a product is equal to the ___ of the logarithms of the separate factors.

---

sum

---

15. $\log 100{,}000 = \log (1{,}000 \times 100)$

$$= \log 1{,}000 + \log \_\_\_$$

$$= \quad 3 + \_\_\_$$

$$= \_\_\_$$

---

log 1,000 + log **100**

= 3 + **2**

= **5**

---

16.

| log 10 | log 100 | log 1,000 |
|---|---|---|
| = 1 | = 2 | = 3 |

a. Log 31 will fall between log ___ and log ___.

b. Mark the approximate place where log 31 falls on the above scale.

c. Since log 10 = 1 and log 100 = 2, log 31 = a number between ___ and ___.

d. Circle the only equation in the list below which could be correct.

log 31 = 2.85

log 31 = 1.49

log 31 = 3.1

log 31 = $10^{3.1}$

---

a. log **10** and log **100**

b. between log 10 and log 100

c. 1 and 2

d. log 31 = 1.49

---

17. Circle the logarithm of 708 in the list below:

a. 2.85 b. 3.14 c. 7.08 d. 1.63

---

a. 2.85 [Since 708 is between 100 and 1,000, log 708 must be between 2 and 3.]

---

18. log 2 = .30 and log 3 = .48 Therefore,

$$\log 6 = \log (2 \times 3)$$

$$= \log 2 + \log 3$$

$$= \_\_\_ + \_\_\_$$

$$= \_\_\_$$

$.30 + .48$
$.78$

---

19. $\log 2 = .30$ and $\log 7 = .85$ Therefore,

$$\begin{aligned} \log 14 &= \log (2 \times 7) \\ &= \log \underline{\quad\quad} + \log \underline{\quad\quad} \\ &= \underline{\quad\quad} + \underline{\quad\quad} \\ &= \underline{\quad\quad} \end{aligned}$$

---

$\log 2 + \log 7$
$30 + .85$
$1.15$

---

20. $\log 2 = .30$ and $\log 3 = .48$. Calculate log 12.

---

$1.08\ [\log 12 = \log 2 + \log 2 + \log 3]$

---

21. The product rule can be used to derive another property of logarithms:

$$\begin{aligned} \log a^3 &= \log (\underline{\quad\quad} \times \underline{\quad\quad} \times \underline{\quad\quad}) \\ &= \log \underline{\quad\quad} + \log \underline{\quad\quad} + \log \underline{\quad\quad} \\ &= \underline{\quad\quad} \log a \end{aligned}$$

In general, $\log a^n = \underline{\quad\quad} \log \underline{\quad\quad}$

---

$a \times a \times a$
$\log a + \log a + \log a$
$3 \log a$
$n \log a$

---

22. $\log 7^9 = \underline{\quad\quad} \log \underline{\quad\quad}$

---

$9 \log 7$

---

23. $\log 2 = .3$
$\log 4 = \log 2^2 = \underline{\quad\quad} \log 2 = \underline{\quad\quad}$
$\log 8 = \underline{\quad\quad} = \underline{\quad\quad\quad\quad} = \underline{\quad\quad}$
$\log 16 = \underline{\quad\quad} = \underline{\quad\quad\quad\quad} = \underline{\quad\quad}$

---

$2 \log 2 = .6$
$\log 2^3 = 3 \log 2 = .9$
$\log 2^4 = 4 \log 2 = 1.2$

---

24. A logarithm rule for division can also be derived.

$$\frac{10^5}{10^3} = \frac{10 \times 10 \times 10 \times 10 \times 10}{10 \times 10 \times 10} = 10^{\underline{\quad}}$$

$$\frac{10^{24}}{10^{18}} = 10^{\underline{\quad}}$$

---

$10^2$
$10^6$

---

25. As the previous frame illustrates, the logarithm of a quotient is equal to the logarithm of the numerator ______ the logarithm of the denominator.

---

minus

---

26. log (35/21) = log ____ − log ____

---

log 35 − log 21

---

27. log 3 = .48 and log 2 = .30

$$\begin{aligned} \log 1\tfrac{1}{2} &= \log(\_\_\_/\_\_\_) \\ &= \log \_\_\_ - \log \_\_\_ \\ &= \_\_\_ - \_\_\_ \\ &= \_\_\_ \end{aligned}$$

---

$$\begin{aligned} &\log(3/2) \\ &= \log 3 - \log 2 \\ &= .48 - .30 \\ &= .18 \end{aligned}$$

---

28. log 2 = .30 log 10 = 1.00

Using the quotient rule, calculate log 5.

$$\begin{aligned} \log 5 &= \log(\_\_\_/\_\_\_) \\ &= \log \_\_\_ - \log \_\_\_ \\ &= \_\_\_ - \_\_\_ \\ &= \_\_\_ \end{aligned}$$

---

$$\begin{aligned} \log 5 &= \log(10/2) \\ &= \log 10 - \log 2 \\ &= 1.00 - .30 \\ &= .70 \end{aligned}$$

---

29. log (3/2) = log 3 − log 2 = .48 − .30 = .18

log (2/3) = ________ = ______ = __

---

log 2 − log 3 = .30 − .48 = −.18

---

30. log (7/5) = .15 log 2 = .3

log (5/7) = ____ log (1/2) = ____

---

−.15

−.3

31. Since $1 = a/a$, log 1 may be calculated by using the quotient rule:

$$\begin{aligned}\log 1 &= \log (a/a)\\ &= \log \_\_\_\_ - \log \_\_\_\_\\ &= \_\_\_\_ \text{(regardless of what } a \text{ equals)}\end{aligned}$$

---

log a — log a

0

---

32. In frame 30 it was seen that log $(1/2) = -.3$ because log $2 = .3$. Show that this same result is obtained by using the quotient rule:

$$\begin{aligned}\log (1/2) &= \_\_\_\_ - \_\_\_\_\\ &= \_\_\_\_ - \_\_\_\_\\ &= \_\_\_\_\end{aligned}$$

---

log 1 — log 2

0 — .3

— .3

---

33. Circle all the numbers in the list below which have negative logarithms:

a. 10 b. 3.5 c. 1/3 d. .7 e. 4/9 f. 9/4

---

c, d, and e [all numbers less than 1]

---

## THE DECIBEL

34. There are two common ways of comparing two numbers, $X$ and $S$:

The difference: $X - S$

The ratio: $X/S$

Stick $X$ is 60 feet long and is to be compared to a standard stick, S, which is 6 feet long. Which statement below makes a *difference* comparison between $X$ and S? ____. Which statement below makes a *ratio* comparison between $X$ and S? ____.

a. Stick $X$ is 10 times longer than stick S.

b. Stick $X$ is 54 feet longer than stick S.

---

b

a

---

35. $X$ is twice as great as S. That is, $X/S =$ ____. Stick X is 1,000 times longer than stick S. That is, $X/S =$ ____. The loudness of tone $X$ is equal to 4 times the loudness of a standard tone S. That is, $X/S =$ ____.

---

2

1,000

4

---

36. It is also possible to make a logarithmic comparison between two numbers. The formula employed for this purpose is: 20 log $(X/S)$.

It is clear that this is simply a logarithmic measure of:

a. The ratio between $X$ and $S$.
b. The difference between $X$ and $S$. Circle one.

---

a. The ratio between $X$ and $S$.

---

37. When $X$ is compared to $S$, the formula $20 \log (X/S)$ is said to give the number of decibels (db) that $X$ is above $S$. Suppose that stick $X$ is 400 feet long and the standard stick $S$ is 4 feet long.

$X/S =$ ____/____ = ____
$\log (X/S) = \log$ (____) = ____
$20 \log (X/S) = 20$ (____) = ____ decibels (db)

In other words, a measurement $X$ which is ____ times greater than the standard $S$ is ____ decibels above $S$.

---

$X/S = 400/4 = 100$
$\log (X/S) = \log (100) = 2$
$20 \log (X/S) = 20\,(2) = 40$ decibels
100
40

---

38. A tone $X$ has a sound pressure that is 1,000 times greater than a standard sound pressure $S$. How many decibels above the standard sound pressure is tone $X$?

$X/S =$ ____
$\log (X/S) =$ ____
$20 \log (X/S) =$ ____ db

---

$X/S = 1{,}000$
$\log (X/S) = 3$
$20 \log (X/S) = 60$ db

---

39. The softest sound pressure that a listener can detect reliably is called the threshold of hearing. It is often used as the standard sound pressure $S$, and other sound pressures are measured relative to it. The normal human ear can receive a sound pressure approximately 1,000,000 times greater than the threshold before the sound becomes painful. If this painful intensity is called $X$, then $X/S = 1{,}000{,}000 = 10^6$. Use the decibel formula again to calculate how many decibels $X$ is above the threshold sound pressure $S$: ____ db.

---

120 db [$20 \log 1{,}000{,}000 = 20 \times 6 = 120$]

---

40. When the threshold of hearing is used as the standard sound pressure, the symbol (SPL), for Sound *P*ressure *L*evel, is written after the word *decibel*. Thus, the exact answer to question 39 is: 120 db (SPL). A soft whisper has a sound pressure $X$ about 10 times greater than the threshold of hearing $S$. How many decibels (SPL) is a soft whisper? ____

---

20 db (SPL) or 20 decibels (SPL) [$20 \log 10 = 20 \times 1 = 20$]

---

41. A subject in a psychological experiment was asked to adjust the loudness of a tone $A$ equal to 2 times a standard tone $B$ ($A/B = 2$). He was asked, therefore, to produce a loudness that was how many decibels above the standard? [Remember, $\log 2 = .3$] ____ db.

---

6 db [$20 \log 2 = 20 \times .3 = 6$]

---

42. The subject was also asked to produce a tone whose loudness was 1/2 the standard. He was asked, therefore, to produce a loudness of how many decibels relative to the standard? ____ db.

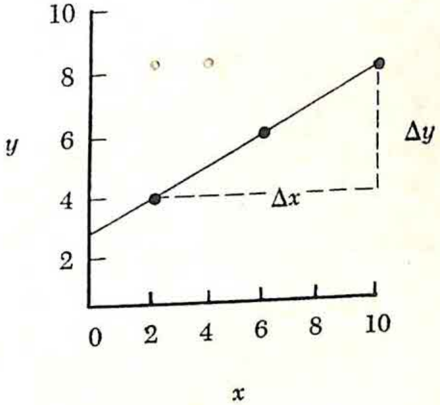
---

—6 db (or 6 db *below* the standard) [$20 \log (1/2) = 20 \times (-.3) = -6$]

---

## THE USE OF LOGARITHMS AND DECIBELS IN GRAPHING

43. The solid line in the graph below represents the results of a hypothetical psychological experiment in which some measure ($y$) of a subject's behavior was determined for each value of a stimulus variable ($x$). As the value of $x$ increases, the value of $y$ ______.



---

increases

---

44. The symbol $\Delta y$ ("delta $y$") is used to designate any arbitrary change of the $y$ variable, and $\Delta x$ designates the *corresponding* change in the $x$ variable. In the graph above, $\Delta y$ designates an increase of four units of the $y$ variable; $\Delta x$ designates the corresponding increase of ______ units of the $x$ variable.

---

8 [from 2 to 10]

---

45. The ratio $\Delta y/\Delta x$ is called the *slope* of the function and indicates how "steep" the function is. The slope of the function in the graph above is ____/____ = ____.

$4/8 = 1/2$

---

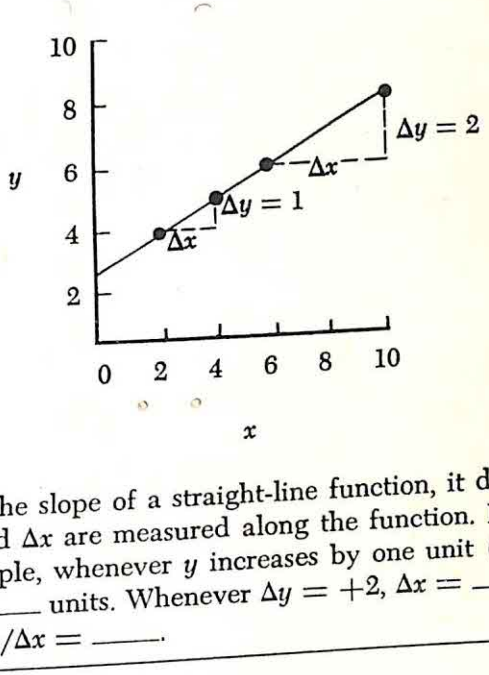
46. The slope of a straight-line function is the ratio between an arbitrary change in the $y$ variable, symbolized Δ____, and the corresponding change in the $x$ variable, symbolized Δ____. Thus, the slope of a straight line is given by Δ____/Δ____.

---

$\Delta y$
$\Delta x$
$\Delta y/\Delta x$

---

47.



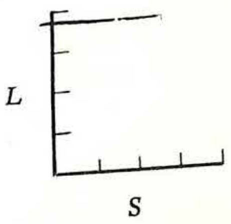
In determining the slope of a straight-line function, it does not matter where $\Delta y$ and $\Delta x$ are measured along the function. In the graph shown, for example, whenever $y$ increases by one unit ($\Delta y = +1$), $x$ increases by ____ units. Whenever $\Delta y = +2$, $\Delta x =$ ____. In each case, slope $= \Delta y/\Delta x =$ ____.

---

2
4
1/2

---

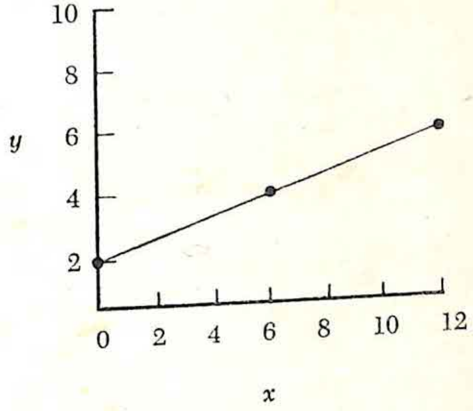
48. If a straight-line function were drawn in the coordinates labeled $L$ and S below, what would be the formula for the slope of the function? Slope = Δ____/Δ____.



$\Delta L/\Delta S$

---

49. Calculate the slope of the function below. Slope = ____. This function is
a. Less "steep" than that shown in frame 47.
b. "Steeper" than that shown in frame 47. (Circle one.)



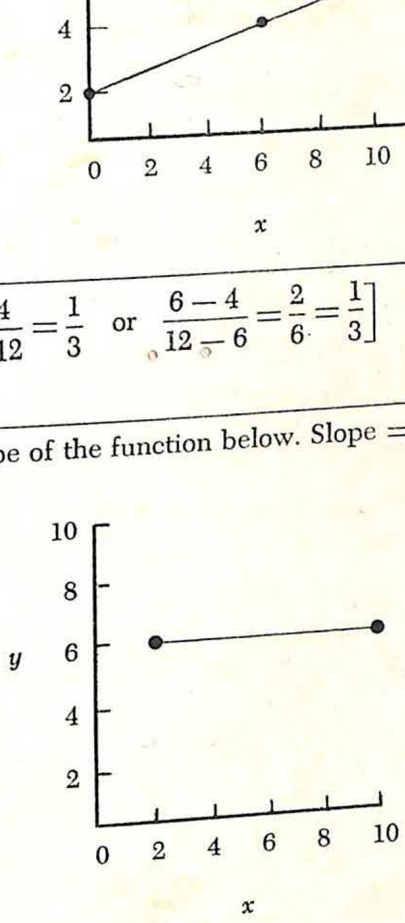
---

1/3 $\left[\frac{6-2}{12-0}=\frac{4}{12}=\frac{1}{3}\text{ or }\frac{6-4}{12-6}=\frac{2}{6}=\frac{1}{3}\right]$

a. less steep

---

50. Calculate the slope of the function below. Slope = $\Delta y/\Delta x$ = ____/8 = ____.

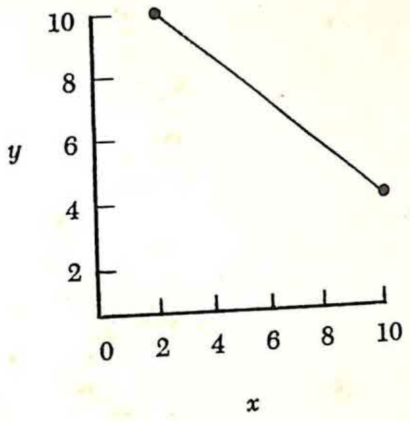


---

0/8 = 0 [$\Delta y = 0$ everywhere. Therefore, $\Delta y/\Delta x = 0$.]

---

51. In the function below, as $x$ increases from 2 to 10 (i.e., $\Delta x = +8$), the corresponding $\Delta y = -$ ____. What is the slope of the function?

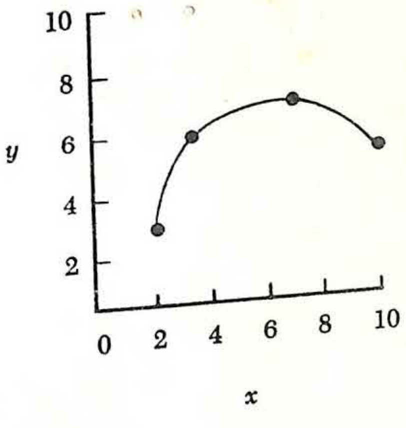


---

$\Delta y = -6$ (from 10 to 4)
$-6/8 = -3/4$

---

52. What property of the function shown below makes it impossible to determine its slope by the method used in previous frames?



---

The function is not a straight line, or the slope is different at each point, or the slope is not constant, etc.

---

53. The function in the previous frame illustrates a general rule: If the slope of a function is a constant number (positive, negative, or zero), then the points of the function lie in a ______ ______.

---

straight line

54. $\Delta y = 3\Delta x$ is an equation that represents a straight-line function because it can be rewritten in the form $\Delta y/\Delta x =$ ____, demonstrating that the ______ of the function is a constant.

---

3
slope

---

55. Two variables in an experiment are related so that $y = 2x$. Thus, when $x$ increases from 0 to 1, $y$ increases from 0 to _____. In general, whenever $x$ changes by one unit ($\Delta x = 1$), $y$ changes by ____ unit(s) ($\Delta y =$ _____).

---

2
2
2

---

56. According to the previous frame, if $y = 2x$, then $\Delta y = 2\Delta x$. In other words, the equation $y = 2x$ also represents a straight-line function, and it has a slope of _____.

---

2

---

57. If a psychologist suspects that two variables in an experiment are related so that $y = nx$, where $n$ is some unknown constant, he can test for this relation by displaying his results in a graph and assessing how closely the points fit on a straight line. What feature of the graph gives the value of the unknown constant $n$?

---

The slope of the function will equal $n$.

---

58. Circle the one equation below that does NOT represent a straight-line function.

a. $\Delta y/\Delta x = -.65$
b. $y = 8x$
c. $y = x^n$
d. $\Delta y = 5\Delta x$

---

c. $y = x^n$

---

59. A standard tone is presented to a subject who is then asked to adjust the tone so that its loudness equals 2 times the standard, 4 times the standard, and 8 times the standard, successively. The experimenter wishes to test the hypothesis that the loudness $L$ (relative to the standard) requested from the subject is related by the following equation to the sound pressure $S$ (relative to a standard) produced by the subject: $L = S^n$, where $n$ is some unknown constant. Does this equation describe a straight line?

---

No.

---

60. Write the variables $L$ and $S$ and the constant $n$ in an equation so that $L$ is related to $S$ by a straight line with slope $n$. ____ = ____

---

$L = nS$

---

61. The function $L = S^n$, which is not a straight line, can be transformed to the function $L = nS$, which is a straight line. Complete the proof below, which shows that this can be done if the two variables $L$ and $S$ are expressed in decibels.

$$L = S^n$$
$$\log L = \log S^n$$
$$\log L = \_\_\_\_ \log S$$
$$20 \log L = \_\_\_\_ \,[20 \log S]$$
$$L_{db} = \_\_\_\_ \,\_\_\_\__{db}$$
$$\text{Therefore, } \Delta L_{db} = \_\_\_\_ \,\Delta\,\_\_\_\__{db}$$
$$\text{Slope} = \Delta L_{db}/\Delta S_{db} = \_\_\_\_.$$

---

$n$

$n$

$nS$

$n\Delta S$

$n$ [The last two steps were seen in frame 56.]

---

62. The proof in the previous frame demonstrates that the function $L = S^n$ can be transformed into a straight-line function if $L$ and $S$ are converted to decibels (or any logarithmic units). According to the result of the proof, what feature of the graph gives the constant, $n$?

---

The slope of the function will be equal to $n$.

---

63. The subject in the experiment described is asked to produce loudnesses ($L$) that are 2 times, 4 times, and 8 times the standard. By using the formula, convert these loudnesses to decibels relative to the standard.

*Standard:* $20 \log 1 = 20 \times 0 = 0$ db
*2 times:* $20 \log 2 = 20\,(.3) = \_\_\_\_$ db
*4 times:* $20 \log 4 = 20 \log 2^2 = 40 \log 2 = 40\,(.3) = \_\_\_\_$ db
*8 times:* $20 \log \_ = \_\_\_\_ = \_\_\_\_ = \_\_\_\_ = \_\_\_\_$ db

---

6 db

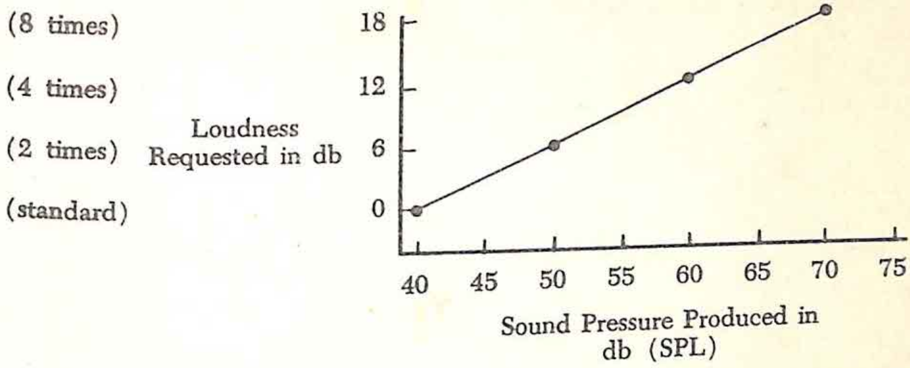
12 db

$20 \log 8 = 20 \log 2^3 = 60 \log 2 = 60\,(.3) = 18$ db

---

64. The graph below illustrates the way in which the data from this experiment would be displayed. It relates the loudness ($L$) requested from the subject to the sound pressure levels ($S$) produced by him.

Both variables are expressed in decibels. What sound pressure did the subject produce when asked for a loudness 4 times the standard loudness? ______ db (SPL)



60 db (SPL)

65. The symbol (SPL) stands for Sound *P*ressure *L*evel and indicates that a particular standard is being used for the decibel values on the *S* axis. What is this standard sound pressure called?

The threshold of hearing.

66. The data displayed in the graph in frame 64 do yield a straight line when $L$ and $S$ are expressed in decibels, thus confirming the hypothesis that the relation between $L$ and $S$ is a power function. That is, $L = S^n$. According to frame 62, how can the unknown exponent $n$ be determined from the graph?

$n$ is equal to the slope of the function.

67. Calculate the slope of the function shown in frame 64. Slope = ______

6/10 or 3/5 or .6

68. A graph may therefore be used to test a set of data to see whether the relation between two variables is of the form $y = x^n$, where $n$ is an unknown constant. This may be done if both $x$ and $y$ are expressed in ______. If the relation has the hypothesized form, what will the graph of the function look like? ______. If the relation has the hypothesized form, how would the constant $n$ (the exponent of the power function) be determined from the graph?

decibels (or any logarithmic units).
The function will be a straight line.
The slope of the function will equal $n$.

## POST-TEST

1. "The common logarithm of 345 is 2.54." Circle all the equations below that are equivalent to this statement.

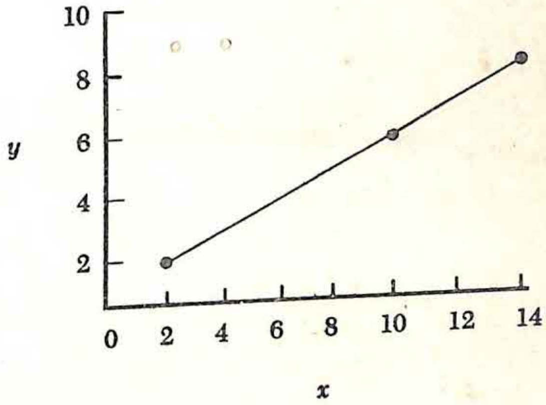
   a. $\log 2.54 = 345$
   b. $\log 345 = 2.54$
   c. $345 = 10^{2.54}$
   d. $2.54^{10} = 345$

2. $\log 2 = .30$
   $\log 3 = .48$
   $\log 5 = .70$
   $\log 7 = .85$
   $\log 9 = .95$

   Calculate: $\log 35$
   $\log 5/3$
   $\log 1/2$
   $\log 9^8$

3. A soft conversational voice has a sound pressure $X$ that is approximately 1,000 times greater than the threshold of hearing $S$. Use the decibel formula to calculate this sound pressure in decibels (SPL).

4. For the function shown below, slope = $\Delta$_____/$\Delta$_____ = _____



5. Circle any equations below that do NOT represent straight-line functions.

   a. $\Delta y = 17\Delta x$
   b. $y = x^3$
   c. $\Delta y/\Delta x = -2$
   d. $y = 4x$

6. By displaying the results of an experiment in a graph, a psychologist wishes to test the hypothesis that the relation between two variables $x$ and $y$ is given by a function of the following form: $y = x^n$, where $n$ is some unknown constant.

   a. What kind of measurement units should be used for expressing $x$ and $y$ on the axes of the graph?

b. If the relation has the hypothesized form, what will the graph of the function look like?

c. If the relation has the hypothesized form, how would the unknown power $n$ be determined from the graph?

## ANSWERS TO POST-TEST

| | *Points* |
|---|---|
| 1. b, c | 2 |
| 2. a. 1.55 | 1 |
| b. .22 | 1 |
| c. –.30 | 1 |
| d. 7.60 | 1 |
| 3. 60 db | 3 |
| 4. $\Delta y/\Delta x = 1/2$ | 3 |
| 5. b | 2 |
| 6. a. Decibels (or any logarithmic units). | 2 |
| b. The function will be a straight line. | 2 |
| c. The slope of the function will equal $n$. | 2 |
| Total | 20 |

# DISCRIMINATION AND GENERALIZATION OF AUDITORY STIMULI

"Stimulus generalization" refers to the observation that an operant under the control of a discriminative stimulus with some value on a physical continuum is also partially controlled by stimuli with other values along that continuum. In other words, changes in response probability are functionally related to changes in the properties of the controlling stimuli. This relationship—called, in its graphic representation, the generalization gradient—is one of the most thoroughly investigated phenomena in the analysis of behavior.

The present experiment examines the gradient of response probability obtained when human vocal responding is reinforced in the presence of one intensity of an auditory stimulus and then other intensities are presented.

## METHOD

### SUBJECTS

One experimentally naive college student (*S*) and two experimenters ($E_1$ and $E_2$) are required.*

### APPARATUS

1. The following four items of equipment are wired in series: an oscillator used to generate a pure tone of 1,000 cycles per second (cps); a variable attenuator that enables *E* to reduce the intensity of the tone in decibel steps; a telegraph key that turns on the tone when pressed down; and a pair of earphones that presents the tone to the subject.
2. A vacuum-tube voltmeter (VTVM) is wired in parallel across the circuit between the variable attenuator and the earphones. The VTVM is used when setting the intensity of the tone.
3. A form is supplied on which *S* keeps a Record of Points received for correct responses during discrimination training.
4. A Schedule for Discrimination Training is included in this Manual.
5. A Schedule for Generalization Testing is also provided.

---

* See the comments on "Employing Subjects in Research" in the Guide to Original Research in this Manual.

## PROCEDURE

### ADJUSTING THE EQUIPMENT

1. The oscillator contains a knob that regulates the amplitude of the tone ("gain control"). In order to avoid damaging the equipment, *E* turns the gain control fully counterclockwise.

2. *E* ensures that the oscillator and the VTVM are plugged in and then turns them on.* (If a multiple-outlet box is used, it may be necessary to turn on a switch located on the box.)

3. *E* sets the attenuator to 0 decibels (db) attenuation, the oscillator to 1,000 cps,† and the range selector on the VTVM to the smallest voltage indicated that is larger than .06 volts.‡

4. *E* puts on the earphones, depresses the telegraph key, and advances the gain control of the oscillator until the VTVM reads 06 volts. (This voltage generates approximately 80 decibels, sound pressure level, with Grason-Stadier earphones Model TDH-39.) *E* ensures that a loud pure tone can be heard and that it terminates when the key is released.

### OBTAINING THE DISCRIMINATION

1. $E_2$ hands S a pencil and the Record of Points. He reads S these instructions:

"In this experiment you can earn points simply by saying 'ka' or 'tee' at appropriate times. We can't tell you now when or how these responses are to be used; that is for you to learn. When the experiment begins, you will hear sounds over your earphones, spaced at intervals of about 5 seconds. Each time you respond appropriately to the sound, I will say 'point' and you should chalk up a point for yourself on your record. Try to get as many points as you can; at the end of the experiment we will compare your record with those of the other subjects in our lab today. Are there any questions?" ($E_2$ answers questions by repeating the instructions.)

2. $E_1$ sets the attenuator to the first db value indicated on his Training Schedule—6 db. This step reduces the forthcoming tone from

---

* On some items of equipment, this is accomplished by a toggle switch; on others, a knob must be turned slightly clockwise.

† On oscillators with both a multiplier switch and a fine-tuning control, the switch is set to X10 and the tuning control to 100 in order to provide a frequency of 1,000 cps.

‡ On a VTVM, the setting of the range selector indicates the meter scale to be read. It also shows the location of the decimal point for any values read from that scale. For example, if the range selector is set at the .1 volt position, then the scale ending with the numeral 1 would be employed. The value of a voltage would be read off the scale, and its decimal point moved one place to the left. Thus, the maximum deflection of the needle would be read as .1 volts.

a sound pressure level (SPL) of 80 db to one of 74 db. Similarly, the alternate attenuator setting, 24 db, provides a tone with a sound pressure level of 56 db.

3. $E_1$ depresses the telegraph key, releasing it after one second. $E_2$ listens for S's response, records it on the schedule in front of $E_1$, and says "point" if the response is correct according to the schedule; he says nothing if the response is incorrect.

4. During the next five seconds, $E_1$ sets the attenuator to the next value listed on the schedule. He always spins the attenuator over several steps before setting it to the specified value (even if this value is the same as the preceding one), so that S's responses are not controlled by the clicks produced in setting the attenuator but by the tone intensities themselves. Then $E_1$ presses the telegraph key, presenting the next tone.

5. If all of S's responses are correct during the last ten stimulus presentations, $E_1$ proceeds to test for generalization. If S's last ten responses are not correct, $E_1$ administers the entire Schedule for Discrimination Training again.

Prior to generalization testing, then, the tone at 56 db (SPL) is established as $S^D$ for the "tee" response and as $S^\Delta$ for the "ka" response; the relations are reversed for the tone at 74 db (SPL).

### TESTING FOR GENERALIZATION

1. $E_2$ instructs S as follows: "In this second part of the experiment we will do the same thing we did in the first part. However, I will keep your record of points and you will not know whether your responses are right or wrong. May I have your record?"

2. $E_2$ takes the record of points and places it and a Schedule for Generalization Testing in front of $E_1$ and out of S's sight. (There is, of course, no basis for scoring S's responses to the novel stimuli presented during testing. S was informed to the contrary to ensure consistent responding in the absence of immediate reinforcement.)

3. $E_1$ proceeds as before, presenting all 110 stimuli listed in the Schedule for Generalization Testing. On the schedule in front of $E_1$, $E_2$ records the response to each stimulus.

4. Finally, $E_2$ explains the experiment to S, including the reasons for keeping a record of points during the first part of the experiment and not during the second part.

## RESULTS

1. Plot the frequency of emission of the two responses as a function of the sound pressure level of the stimuli presented during gen-

eralization testing. Indicate the intensities of the training stimuli on the abscissa of the graph.

2. Describe the form of the generalization gradient. (You may wish to compare your results to those reported by Cross and Lane, 1962.)

## DISCUSSION

Consider the following problems when discussing your results.

1. What general statement may be made concerning the degree to which a discriminative response is evoked by stimuli drawn from the same physical continuum as the original discriminative stimulus?

2. What differences did you observe between the time-course of discrimination training in this experiment and that in Experiment 2? In which experiment did the frequency of correct responses increase more abruptly? Discuss differences in the training procedures and Ss employed which might have led to the differences in results.

3. Enumerate the steps of a procedure, parallel to that in the present experiment, for obtaining a generalization gradient with a naive rat. Employ two light intensities and two responses. Establish the high-intensity light as $S^D$ for barpress and $S^\Delta$ for rodpush; conversely, establish the low-intensity light as $S^D$ for rodpush and $S^\Delta$ for barpress.

### References

Cross, D. V., and Lane, H. L. On the discriminative control of concurrent responses: The relations among response frequency, latency, and topography in auditory generalization. *Journal of the experimental analysis of behavior*, 1962, *5*, 487–496.

Holland, J. G., and Skinner, B. F. *The analysis of behavior.* New York: McGraw-Hill, 1961, pp. 137–160.

## Record of Points Received for Correct Responses

Subject's Name ______________________ Date ____________

Instructions: Make a pencil mark on the line for each point you receive.

Total ______

Name ______________________ Lab Hour ______________

Laboratory Instructor ____________ Date ________________

## Schedule for Discrimination Training

| Decibels Attenuation | Response Emitted | Reinforce for | Decibels Attenuation | Response Emitted | Reinforce for |
|---|---|---|---|---|---|
| 6 | ______ | ____ ka | 24 | ______ | ____ tee |
| 24 | ______ | ____ tee | 24 | ______ | ____ tee |
| 24 | ______ | ____ tee | 6 | ______ | ____ ka |
| 6 | ______ | ____ ka | 24 | ______ | ____ tee |
| 6 | ______ | ____ ka | 6 | ______ | ____ ka |
| 24 | ______ | ____ tee | 24 | ______ | ____ tee |
| 24 | ______ | ____ tee | 6 | ______ | ____ ka |
| 6 | ______ | ____ ka | 24 | ______ | ____ tee |
| 24 | ______ | ____ tee | 6 | ______ | ____ ka |
| 6 | ______ | ____ ka | 6 | ______ | ____ ka |
| 24 | ______ | ____ tee | | | |
| 6 | ______ | ____ ka | | | |
| 6 | ______ | ____ ka | | | |
| 6 | ______ | ____ ka | | | |
| 24 | ______ | ____ tee | | | |
| 6 | ______ | ____ ka | | | |
| 6 | ______ | ____ ka | | | |
| 24 | ______ | ____ tee | | | |
| 24 | ______ | ____ tee | | | |
| 24 | ______ | ____ tee | | | |

Name ______________________ Lab Hour ______________

Laboratory Instructor ______________ Date ____________________

## Schedule for Generalization Testing

| Decibels Attenuation | Response | Decibels Attenuation | Response | Decibels Attenuation | Response |
|---|---|---|---|---|---|
| 3 | | 15 | | 24 | |
| 9 | | 12 | | 9 | |
| 21 | | 0 | | 27 | |
| 0 | | 9 | | 30 | |
| 15 | | 18 | | 15 | |
| 27 | | 30 | | 6 | |
| 18 | | 21 | | 12 | |
| 6 | | 6 | | 3 | |
| 24 | | 3 | | 21 | |
| 12 | | 24 | | 18 | |
| 30 | | 27 | | 0 | |
| | | | | | |
| 9 | | 12 | | 18 | |
| 12 | | 24 | | 9 | |
| 6 | | 30 | | 3 | |
| 27 | | 0 | | 15 | |
| 15 | | 21 | | 30 | |
| 18 | | 3 | | 6 | |
| 21 | | 27 | | 21 | |
| 30 | | 9 | | 24 | |
| 3 | | 6 | | 27 | |
| 0 | | 18 | | 0 | |
| 24 | | 15 | | 12 | |

## Schedule for Generalization Testing (continued)

| Decibels Attenuation | Response | Decibels Attenuation | Response |
|---|---|---|---|
| 21 | ______ | 6 | ______ |
| 27 | ______ | 0 | ______ |
| 24 | ______ | 30 | ______ |
| 18 | ______ | 27 | ______ |
| 3 | ______ | 21 | ______ |
| 12 | ______ | 12 | ______ |
| 9 | ______ | 15 | ______ |
| 15 | ______ | 9 | ______ |
| 0 | ______ | 24 | ______ |
| 6 | ______ | 3 | ______ |
| 30 | ______ | 18 | ______ |
| | | | |
| 24 | ______ | 27 | ______ |
| 21 | ______ | 3 | ______ |
| 15 | ______ | 30 | ______ |
| 0 | ______ | 12 | ______ |
| 27 | ______ | 18 | ______ |
| 6 | ______ | 24 | ______ |
| 9 | ______ | 6 | ______ |
| 30 | ______ | 15 | ______ |
| 18 | ______ | 21 | ______ |
| 12 | ______ | 9 | ______ |
| 3 | ______ | 0 | ______ |

### Summary

| Decibels Attenuation | Number of "tee" Responses | Decibels Sound Pressure Level |
|---|---|---|
| 0 | ______ | 80 |
| 3 | ______ | 77 |
| 6 | ______ | 74 |
| 9 | ______ | 71 |
| 12 | ______ | 68 |
| 15 | ______ | 65 |
| 18 | ______ | 62 |
| 21 | ______ | 59 |
| 24 | ______ | 56 |
| 27 | ______ | 53 |
| 30 | ______ | 50 |

Evaluation Form

# DISCRIMINATION AND GENERALIZATION OF AUDITORY STIMULI

(Submit this form with your laboratory report.)

1. The laboratory report required about ______ minutes to complete.
2. The experiment required about ______ minutes to complete.
3. The following malfunctions of the equipment occurred:

4. Other features of the experiment which caused difficulty were:

5. This experiment was conducted in section number ______.

# THRESHOLDS FOR PURE-TONE STIMULI BEFORE AND AFTER AUDITORY FATIGUE

Previous experiments in this manual examined the effectiveness of discriminative stimuli as secondary reinforcers and their specificity of control over operant behavior. This experiment explores a third property of discriminative stimuli and an important area of psychological measurement: stimulus thresholds. The threshold value of a stimulus is the minimum intensity required to evoke a response. Like other properties of discriminative stimuli, the threshold value is affected by the kind and degree of prior training, motivational variables, physiological operations on the organism, and the conditions under which the threshold is determined. After nearly a century of research in psychophysics, standardized techniques have evolved which eliminate or hold constant many of these extraneous variables. This experiment simply adopts one of the standard techniques, the method of adjustment, in order to determine auditory thresholds. The minimum intensity of an auditory stimulus required to evoke a response is determined as a function of a second variable property of the stimulus, its frequency. These threshold determinations are made before and after prolonged exposure to a tone of high intensity.

## METHOD

### SUBJECTS

The members of the laboratory section work in pairs. One student serves as *E*, one as S.

### APPARATUS

1. The apparatus of Experiment 6 is used again: an oscillator, a variable attenuator (with tape obscuring its scale), a VTVM, a telegraph key (with a rubber band to keep it closed during the production of auditory fatigue), and a pair of earphones. In addition, a 60-db attenuator is interposed between the variable attenuator and the earphones, in parallel with the telegraph key When high voltages, large enough to be read on the VTVM, are applied to the input of the attenuator, then low voltages (60 db less), which are small enough to produce tones with near-

threshold intensities, appear at the output of the attenuator and therefore across the earphones.

2. A Data Form and Schedule of Test Frequencies is provided for recording the threshold measurements.

3. A Conversion Table is included in the Manual for converting threshold measurements, in volts supplied to the earphones, to decibels of sound pressure, generated by the earphones.

## PROCEDURE

### ADJUSTING THE EQUIPMENT

1. Before turning on the equipment, *E* sets the range selector on the VTVM to the highest voltage setting.

2. *E* sets the oscillator to 175 cps (multiplier switch to X1, fine-tuning control to 175) and turns the gain control to full counterclockwise position.

3. *E* ensures that the oscillator and the VTVM are plugged in and then turns them on.

4. *E* puts on the earphones, turns the variable attenuator to 0 db attenuation (fully clockwise), and advances the gain control of the oscillator until a soft tone is heard.

5. *E* turns the range selector on the VTVM counterclockwise until the needle deflects about halfway across the face of the meter.

### MEASURING AUDITORY THRESHOLDS

1. *E* instructs *S* as follows: "When I tell you to start, rotate the knob on the variable attenuator until the sound in the earphones is gone. Then turn the knob in the other direction until the sound reappears. Repeat this bracketing procedure, each time decreasing the width of your bracket, until you have 'homed in' on the point at which the sound just appears."

2. *E* sets the oscillator to the first frequency specified on the schedule and instructs *S* to put on the earphones and begin his first threshold setting. (If *S* is unable to reduce the level of the tone to threshold within the range of the attenuator, *E* reduces the oscillator gain slightly.)

3. When *S* indicates that he has completed his threshold setting, *E* switches the range selector on the VTVM to obtain a readable needle deflection and records the voltage on the Data Form.*

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* Detailed instructions for reading a voltmeter appear in the procedure section of Experiment 6.

4. *S* is instructed to turn the variable attenuator fully counterclockwise. *E* switches the range selector on the VTVM to a higher position again, so that the meter will not be damaged accidentally when the next determination is made. He then sets the oscillator to the next frequency shown on the schedule and makes another determination of threshold. This procedure is repeated until threshold measurements have been obtained at each of the 24 frequencies listed in the schedule.

### PRODUCING AUDITORY FATIGUE

1. S takes off the earphones and sets the variable attenuator to 0 db (fully clockwise).

2. *E* sets the range selector on the VTVM to 1 volt or the next largest setting available.

3. *E* sets the oscillator to 2,800 cps and slowly advances its gain control until the VTVM reads 1.0 volt. (This voltage generates approximately 104 decibels, sound pressure level, when applied directly to the Grason-Stadler earphones, Model TDH-39.)

4. *E* depresses the telegraph key and keeps it closed by placing a rubber band around it. He then turns the variable attenuator halfway through its excursion.

5. S puts on the earphones and turns the variable attenuator fully clockwise to 0 db. *E* ensures that the VTVM reads 1.0 volt and begins timing the 15-minute period of exposure.

6. During the exposure period, *E* processes the measurements obtained earlier. For each voltage recorded in column 4 of the Data Form, *E* looks in the Conversion Table provided in the Manual and determines the corresponding number of decibels, sound pressure level, which he records in column 5 of the Data Form. Then he transcribes these data onto the form in S's Manual without revealing them. S may read during the exposure period.

### MEASURING THE THRESHOLDS AFTER AUDITORY FATIGUE

1. After 15 minutes of exposure have elapsed, *E* releases the telegraph key and instructs S to make a threshold determination by adjusting the variable attenuator. (If S is unable to set the threshold intensity within the range of the attenuator, *E* reduces the oscillator gain slightly.)

2. *E* repeats the procedure for threshold measurement until all 24 frequencies listed in the schedule have been presented.

3. Finally, S removes the earphones and transcribes the threshold measurements just obtained onto the Data Form in his Manual.

## RESULTS

1. Plot the average sound pressure level (in decibels) [*] as a function of the frequency of the stimulus tone. The appropriate coordinates are illustrated below. Prepare two threshold curves on the same coördinates—one for the measurements obtained before auditory fatigue and one for those obtained after it.

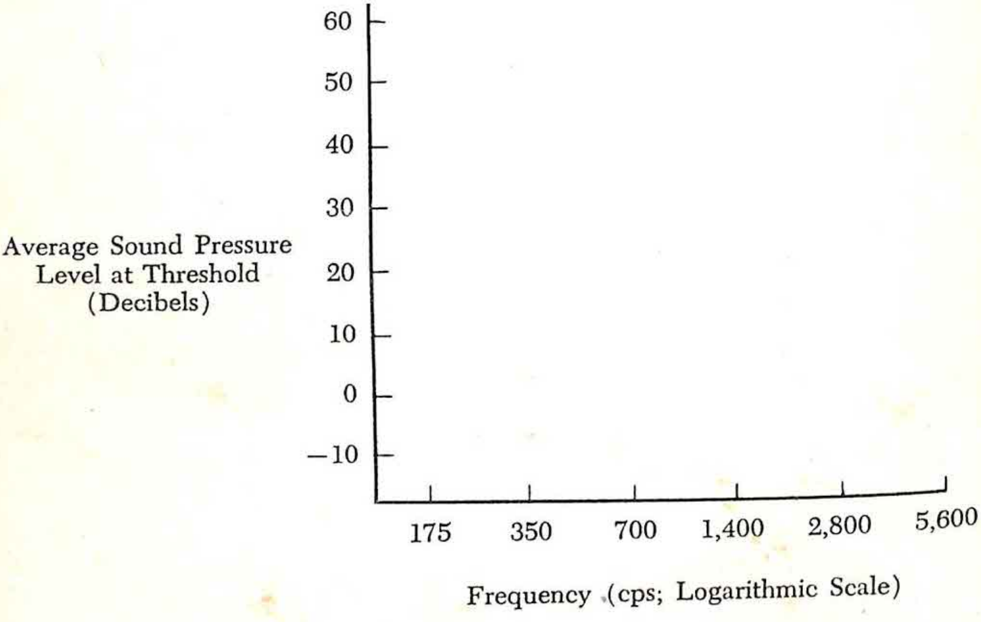

**Figure 1**

2. Describe the form of the threshold function before auditory fatigue, noting the frequencies at which maximum and minimum sensitivity were observed.

3. Describe the effects on the threshold curve of exposing the listener to a loud, pure tone for a prolonged period. In particular, report whether the auditory threshold was elevated at the exposure frequency or at adjacent frequencies. To illustrate graphically the effects of auditory fatigue on the threshold function, plot for each frequency the average threshold measurement obtained after exposure minus that obtained before exposure. Use the coordinates of an audiogram, which are illustrated below. The audiogram representation readily reveals deviations in sensitivity from

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[*] The program in this Manual explains logarithms and decibels.

a baseline threshold. For this reason, audiograms are widely used in clinical practice to depict hearing loss.

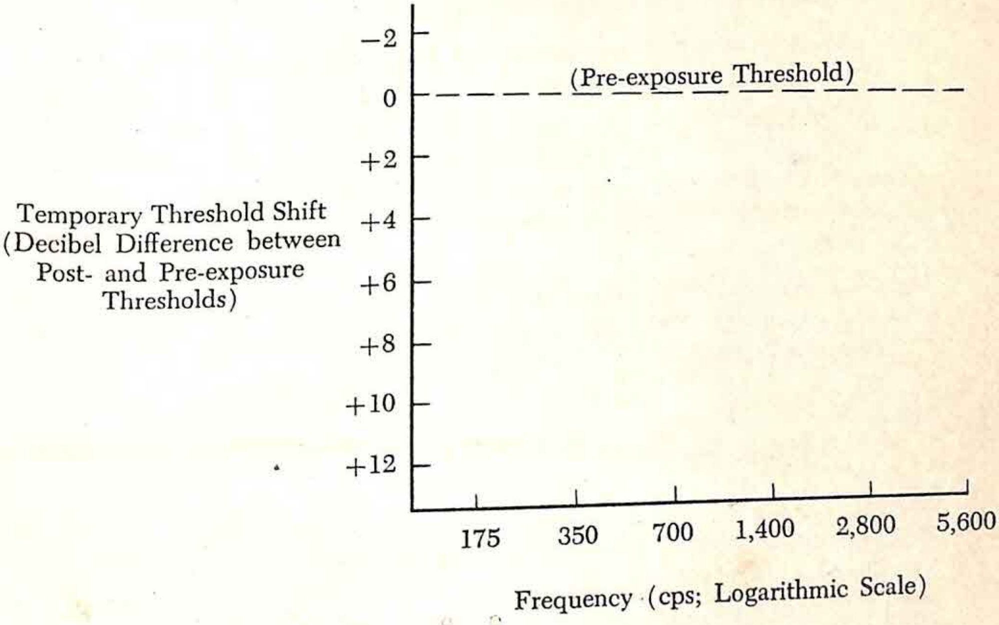

**Figure 2**

## DISCUSSION

Consider the following problems when discussing your results.

1. How does the threshold function that you collected before auditory fatigue compare with the classical data reported by Sivian and White (1953), tabulated below?

**TABLE 1. Auditory Threshold Measurements on 22 Listeners**

| Stimulus Frequency (cps) | Average Sound Pressure Level at Threshold (Decibels) |
|---|---|
| 175 | 30 |
| 350 | 14 |
| 700 | 3 |
| 1,400 | 1 |
| 2,800 | 3 |
| 5,600 | 13 (extrapolated) |

To facilitate this comparison, plot these data along with your threshold functions in Figure 1. Are there systematic differences between these functions in shape or vertical position? What variables may have produced these differences?

2. Design a technique for determining auditory thresholds in the rat. Describe the procedures for conditioning and maintaining the discriminative behavior. What additional procedures might you employ to ensure that the rat's behavior is strictly under discriminative control of the auditory stimulus? (For a description of behavioral techniques in threshold measurement with animals, see Blough, 1958.)

3. How would the threshold function obtained after auditory fatigue change if the order of presentation of the test frequencies were reversed?

## References

Blough, D. A method for determining psychophysical thresholds in the pigeon. *Journal of the experimental analysis of behavior*, 1958, *1*, 32–43.

Sivian, L. J., and White, S. D. On minimum audible sound fields. Cited in Geldard, F. S., *The human senses*. New York: Wiley & Sons, 1953.

Name ______________________ Lab Hour ______________

Laboratory Instructor ____________ Date ______________

## Data Form and Schedule of Test Frequencies

| Oscillator | | | Pre-exposure Threshold Determination | | | | Post-exposure Threshold Determination | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Volts | | | db | Volts | | | db |
| Fine-Tuning Control × | Multiplier Switch = | Frequency (cps) | Meter × | Range = | Reading | | Meter × | Range = | Reading | |
| 28 | 100 | 2,800 | | | | | | | | |
| 28 | 100 | 2,800 | | | | | | | | |
| 28 | 100 | 2,800 | | | | | | | | |
| 28 | 100 | 2,800 | | | | | | | | |
| | | | Sum | | | | Sum | | | |
| | | | Average | | | | Average | | | |
| 175 | 1 | 175 | | | | | | | | |
| 175 | 1 | 175 | | | | | | | | |
| 175 | 1 | 175 | | | | | | | | |
| 175 | 1 | 175 | | | | | | | | |
| | | | Sum | | | | Sum | | | |
| | | | Average | | | | Average | | | |
| 56 | 100 | 5,600 | | | | | | | | |
| 56 | 100 | 5,600 | | | | | | | | |
| 56 | 100 | 5,600 | | | | | | | | |
| 56 | 100 | 5,600 | | | | | | | | |
| | | | Sum | | | | Sum | | | |
| | | | Average | | | | Average | | | |

## Data Form and Schedule of Test Frequencies (continued)

| Oscillator | | | Pre-exposure Threshold Determination | | | | Post-exposure Threshold Determination | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fine-Tuning Control × | Multiplier Switch = | Frequency (cps) | Volts | | | db | Volts | | | db |
| | | | Meter × | Range = | Reading | | Meter × | Range = | Reading | |
| 140 | 10 | 1,400 | | | | | | | | |
| 140 | 10 | 1,400 | | | | | | | | |
| 140 | 10 | 1,400 | | | | | | | | |
| 140 | 10 | 1,400 | | | | | | | | |
| | | | Sum | | | | Sum | | | |
| | | | Average | | | | Average | | | |
| 35 | 10 | 350 | | | | | | | | |
| 35 | 10 | 350 | | | | | | | | |
| 35 | 10 | 350 | | | | | | | | |
| 35 | 10 | 350 | | | | | | | | |
| | | | Sum | | | | Sum | | | |
| | | | Average | | | | Average | | | |
| 70 | 10 | 700 | | | | | | | | |
| 70 | 10 | 700 | | | | | | | | |
| 70 | 10 | 700 | | | | | | | | |
| 70 | 10 | 700 | | | | | | | | |
| | | | Sum | | | | Sum | | | |
| | | | Average | | | | Average | | | |

## Conversion Table

(Given: volts at threshold setting. Find: decibels, sound pressure level, generated at earphones.)

| (1) | (2) | (3) | (4) |
|---|---|---|---|
| Volts at Threshold Setting | Decibels Re: 1 Volt | Voltage Applied to Each Earphone in db Re: 1 Volt ° | Sound Pressure Level at Each Earphone in Decibels † |
| 10.0 | +20 | −46 | 64 |
| 8.9 | 19 | −47 | 63 |
| 7.9 | 18 | −48 | 62 |
| 7.1 | 17 | −49 | 61 |
| 6.3 | 16 | −50 | 60 |
| 5.6 | 15 | −51 | 59 |
| 5.0 | 14 | −52 | 58 |
| 4.5 | 13 | −53 | 57 |
| 4.0 | 12 | −54 | 56 |
| 3.5 | 11 | −55 | 55 |
| 3.2 | 10 | −56 | 54 |
| 2.8 | 9 | −57 | 53 |
| 2.5 | 8 | −58 | 52 |
| 2.2 | 7 | −59 | 51 |
| 2.0 | 6 | −60 | 50 |
| 1.8 | 5 | −61 | 49 |
| 1.6 | 4 | −62 | 48 |
| 1.4 | 3 | −63 | 47 |
| 1.3 | 2 | −64 | 46 |
| 1.1 | 1 | −65 | 45 |
| 1.0 | 0 | −66 | 44 |
| .89 | −1 | −67 | 43 |
| .79 | −2 | −68 | 42 |
| .71 | −3 | −69 | 41 |
| .63 | −4 | −70 | 40 |
| .56 | −5 | −71 | 39 |
| .50 | −6 | −72 | 38 |
| .45 | −7 | −73 | 37 |
| .40 | −8 | −74 | 36 |
| .35 | −9 | −75 | 35 |
| .32 | −10 | −76 | 34 |
| .28 | −11 | −77 | 33 |
| .25 | −12 | −78 | 32 |
| .22 | −13 | −79 | 31 |

| (1) Volts at Threshold Setting | (2) Decibels Re: 1 Volt | (3) Voltage Applied to Each Earphone in db Re: 1 Volt[°] | (4) Sound Pressure Level at Each Earphone in Decibels[†] |
|---|---|---|---|
| .20 | −14 | −80 | 30 |
| .18 | −15 | −81 | 29 |
| .16 | −16 | −82 | 28 |
| .14 | −17 | −83 | 27 |
| .13 | −18 | −84 | 26 |
| .11 | −19 | −85 | 25 |
| .10 | −20 | −86 | 24 |
| .089 | −21 | −87 | 23 |
| .079 | −22 | −88 | 22 |
| .071 | −23 | −89 | 21 |
| .063 | −24 | −90 | 20 |
| .056 | −25 | −91 | 19 |
| .050 | −26 | −92 | 18 |
| .045 | −27 | −93 | 17 |
| .040 | −28 | −94 | 16 |
| .035 | −29 | −95 | 15 |
| .032 | −30 | −96 | 14 |
| .028 | −31 | −97 | 13 |
| .025 | −32 | −98 | 12 |
| .022 | −33 | −99 | 11 |
| .020 | −34 | −100 | 10 |
| .018 | −35 | −101 | 9 |
| .016 | −36 | −102 | 8 |
| .014 | −37 | −103 | 7 |
| .013 | −38 | −104 | 6 |
| .011 | −39 | −105 | 5 |
| .010 | −40 | −106 | 4 |
| .0089 | −41 | −107 | 3 |
| .0079 | −42 | −108 | 2 |

| (1) Volts at Threshold Setting | (2) Decibels Re: 1 Volt | (3) Voltage Applied to Each Earphone in db Re: 1 Volt ° | (4) Sound Pressure Level at Each Earphone in Decibels † |
|---|---|---|---|
| .0071 | −43 | −109 | 1 |
| .0063 | −44 | −110 | 0 |
| .0056 | −45 | −111 | −1 |
| .0050 | −46 | −112 | −2 |
| .0045 | −47 | −113 | −3 |
| .0040 | −48 | −114 | −4 |
| .0035 | −49 | −115 | −5 |
| .0032 | −50 | −116 | −6 |
| .0028 | −51 | −117 | −7 |
| .0025 | −52 | −118 | −8 |
| .0022 | −53 | −119 | −9 |
| .0020 | −54 | −120 | −10 |
| .0018 | −55 | −121 | −11 |
| .0016 | −56 | −122 | −12 |
| .0014 | −57 | −123 | −13 |
| .0013 | −58 | −124 | −14 |
| .0011 | −59 | −125 | −15 |
| .0010 | −60 | −126 | −16 |

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° The voltage applied to each earphone is 66 decibels less than the voltage read on the VTVM for these reasons: (a) the fixed attenuator delivers to the earphones a voltage 60 db less than that read on the VTVM; (b) each earphone receives only half of the voltage delivered by the attenuator. Thus, the voltage across each earphone is an additional 6 db less than that read on the VTVM (since 20 log 2 = 6 db).

† These computed sound pressure levels apply to Grason-Stadler TDH-39 earphones that deliver 110 db (SPL) when supplied with 1.0 volt at the frequencies employed in this experiment. If other stimulus frequencies or types of earphone are employed, the manufacturer's calibration chart should be consulted. Typically, it will be possible to modify the entries in this column appropriately by adding a constant correction.

## Evaluation Form

# THRESHOLDS FOR PURE-TONE STIMULI BEFORE AND AFTER AUDITORY FATIGUE

(Submit this form with your laboratory report.)

1. The laboratory report required about ______ minutes to complete.

2. The experiment required about ______ minutes to complete.

3. The following malfunctions of the equipment occurred:

4. Other features of the experiment which caused difficulty were:

5. This experiment was conducted in section number ______.

### Experiment 8

# THE DYNAMICS OF HEARING AND AND THE LOUDNESS SCALE

A device that converts one form of energy to another is called a transducer. The earphone is a transducer because it converts changes in electrical energy (voltage) to changes in acoustic energy (sound pressure). The ear is also a transducer because it converts changes in sound pressure, detected by movements of the eardrum, into changes in voltage (actually brief electrical pulses).

An important property of a transducer, and the concern of the present experiment, is its dynamic operating characteristic, the function that relates changes in energy at the input to changes at the output. The operating characteristic of an earphone is typically linear over a large range; that is, a doubling of the voltage applied to the earphone produces a doubling of sound pressure from the earphone. What is the dynamic operating characteristics of the human auditory system? One way of pursuing this question is to inquire into the relation between acoustic events at the input to the ear and neural events at the output. This essentially physiological formulation of the problem focuses on the peripheral hearing mechanism. Psychologists have attempted to answer the question by presenting various sound pressures to a listener and recording some measure of the listener's behavior when he is instructed to judge the loudness of these sounds. Since judgments of loudness serve as an index of the output of the auditory transducer, this approach is indirect, but it is more comprehensive because more of the series of events in auditory perception affect the dependent variable. From this vantage point, if a doubling of sound pressure typically yields a doubling of loudness, then the operating characteristic of the auditory system is linear. On the other hand, if a 100% increase in various sound pressures produces only a 50% increase in loudness, the operating characteristic of the auditory system is nonlinear and, in effect, compresses large changes at the input into smaller changes at the output.

Since the operating characteristic of the auditory system shows the relation between sound pressure levels and some measure of their behavioral effect, it provides the raw materials for constructing a psychological scale of sound pressure. A psychological scale of sound pressure (the loudness scale) involves the assignment of a number to each of the pressures in accord with its loudness, as described by the operating characteristic of the auditory system.

# METHOD

## SUBJECTS

The members of the laboratory section work in pairs. Each student serves once as *E* and once as S.

## APPARATUS

1. The apparatus from Experiment 6 is used again: an oscillator, a variable attenuator, a VTVM, and a pair of earphones. A telegraph key is not needed.

2. A Data Form and Schedule of Loudness Productions are included in this Manual.

## PROCEDURE

### ADJUSTING THE EQUIPMENT

1. *E* turns the gain control on the oscillator fully counterclockwise, ensures that the oscillator and VTVM are plugged in, and turns them on.

2. *E* sets the variable attenuator to 0 db (fully clockwise), the oscillator to 1,000 cps, and the range selector on the VTVM to the smallest indicated voltage larger than .06 volts.

3. *E* puts on the earphones and advances the gain control of the oscillator until the VTVM reads .06 volts. (This voltage generates approximately 80 decibels, sound pressure level, with the Grason-Stadler earphones, Model TDH-39.) *E* ensures that a loud, pure tone is heard.

### OBTAINING THE LOUDNESS PRODUCTIONS

1. *E* instructs S as follows: "When you put on the earphones, you will hear a tone whose loudness will serve as a standard for the rest of the experiment. After you have observed the loudness of the standard tone, I will ask you to set the tone to another loudness proportionate to the loudness of the standard. For example, if I say 'Now set the loudness *two times* the standard,' you should adjust the attenuator until the tone in your earphones sounds twice as loud as the standard. I will then record the setting of the attenuator and instruct you to produce another loudness."

2. *E* ensures that S cannot see the attenuator or the Data Form at any time after the experiment begins.

3. *E* sets the variable attenuator to 40-db attenuation. Thereby, he reduces the sound pressure level of the tone generated by the earphones from 80 db (SPL) to 40 db (SPL), which provides the standard loudness for S.

4. *S* puts on the earphones and listens to the standard loudness. After a few seconds, *E* requests the first loudness production specified in the schedule. He requests this and all other productions by saying, "Now set the loudness —— the standard."

5. After *S* makes his loudness production, *E* records the setting of the attenuator on the Data Form and requests the next loudness production. When the 24 loudness productions have been completed, *E* and *S* interchange roles and replicate the experiment.

## RESULTS

1. Label the vertical axis of a graph "Loudness Production Values in db Re: Standard" and the horizontal axis "Average Sound Pressure Level Produced." Then plot the tabulated corresponding data for your S.* Draw a single straight line through the points on the graph so that the points lie as close as possible to the line. This function describes the dynamic operating characteristic of the auditory system of your S. In order to determine whether or not the auditory system is a linear transducer, calculate approximately the slope of the operating characteristic in the following way. Using the entries on the Data Form, divide the range of loudness values $(y_4 - y_1)$ by the corresponding range of sound pressure levels produced $(x_4 - x_1)$:

$$\text{slope} = \frac{\Delta L_{\text{db}}}{\Delta S_{\text{db}}} = \frac{y_4 - y_1}{x_4 - x_1} = \frac{18 - 0}{(\quad) - (\quad)} = \frac{18}{(\quad)} = \underline{\qquad}$$

where $\Delta L_{\text{db}}$ is a decibel change in loudness and $\Delta S_{\text{db}}$ is a decibel change in sound pressure. If the slope that you have calculated is 1, then a change in sound pressure level $(\Delta S)$ produced an equivalent change in loudness $(\Delta L)$ in your experiment, and you have obtained a linear operating characteristic. If the slope is less than 1, then a change in sound pressure produced a smaller change in loudness, and you have evidence that the auditory system is a nonlinear transducer and, specifically, a compressor. Describe your findings in these terms. (For a discussion of the dynamic operating characteristics of several sensory systems, see Stevens, 1960.)

2. On the basis of extensive prior research, Stevens (1955) has proposed the following operating characteristic, called the "sone function," as a general description of the dynamics of the auditory system:

$$\frac{\Delta L_{\text{db}}}{\Delta S_{\text{db}}} = .6$$

---

* The Program in this Manual explains logarithms and decibels.

In terms of your graph of the operating characteristic, the sone function has the following form:

$$\text{slope} = \frac{\Delta L_{\text{db}}}{\Delta S_{\text{db}}} = \frac{y_4 - y_1}{(x_1 + 30) - x_1} = \frac{18}{30} = .6$$

According to this function, when a subject is instructed to produce an 18-db change in loudness (8 times the standard in your experiment), he will produce a 30-db change in sound pressure, yielding an operating characteristic with a slope of .6. The function obtained in your experiment begins at the point with the coordinates $x_1$, $y_1$, extends over a range of $y_4 - y_1 = 18$ decibels in loudness and $x_4 - x_1 =$ _____ decibels in sound pressure, and arrives at the point $x_4$, $y_4$. The sone function may be drawn so that it begins at the same point, $x_1$, $y_1$. But in extending over a range of $y_4 - y_1 = 18$ decibels in loudness, it must cover a range of $(x_1 + 30) - x_1 = 30$ decibels in sound pressure, arriving at the point $(x_1 + 30)$, $y_4$. Draw the sone function on the same graph that shows the obtained operating characteristic and compare the two functions.

## DISCUSSION

Consider the following problems when discussing your results.

1. Given the loudness function obtained in this experiment, or the standardized "sone function," it is possible to state the loudnesses of sounds when their sound pressure levels are known. Thus, the functions in Figure 1 of your report may be used as scales of measurement for loudness. According to the sone scale of loudness, how many decibels must be added to the sound pressure level of a tone in order to double its loudness? To quadruple its loudness?

2. The scale of length has an arbitrary but constant reference point—a standard length assigned the value "1 inch." The scale of loudness proposed by Stevens, and adopted by the International Standards Organization, also has an arbitrary but constant reference point—a standard sound pressure level for a 1,000-cps tone, 40 decibels, which is assigned the value "1 sone." If a 1,000-cps tone at 40 db (sound pressure level) has a loudness of 1 sone, what is the loudness of a tone at 60 db (SPL)?

3. The following illustration shows the sound pressure levels of various sources of sound together with the standard thresholds of hearing and discomfort (at 1,000 cps). In your report, state the loudness (in sones) of each sound source and threshold, assuming that the sone function has a slope of 0.6 over the range of sound pressure levels 0–160 db.

Sound Pressure Level in Decibels

| | |
|---|---|
| 160 — | Jet Plane with Afterburners |
| — | |
| 140 — | |
| — | |
| 120 — | Threshold of Discomfort |
| — | Subway |
| 100 — | |
| — | |
| 80 — | Heavy Traffic |
| — | Normal Conversation |
| 60 — | |
| — | |
| 40 — | (One Sone) |
| — | Whisper |
| 20 — | |
| — | |
| 0 — | Threshold of Hearing |

### References

Stevens, S. S. The measurement of loudness. *Journal of the acoustical society of America*, 1955, *27*, 812–829.

Stevens, S. S. The psychophysics of sensory function. *American scientist*, 1960, *48*, 226–253.

Name ____________________ Lab Hour ____________________

Laboratory Instructor ____________________ Date ____________________

# Data Form and Schedule of Loudness Productions

| Loudness Productions | Attenuator Setting (db) | Loudness Productions | Attenuator Setting (db) |
|---|---|---|---|
| 2 times | ________ | 2 times | ________ |
| 8 times | ________ | 8 times | ________ |
| 4 times | ________ | 4 times | ________ |
| equal to | ________ | equal to | ________ |
| 8 times | ________ | 8 times | ________ |
| 2 times | ________ | 2 times | ________ |
| equal to | ________ | equal to | ________ |
| 4 times | ________ | 4 times | ________ |
| 8 times | ________ | 8 times | ________ |
| equal to | ________ | equal to | ________ |
| 2 times | ________ | 2 times | ________ |
| 4 times | ________ | 4 times | ________ |

## SUMMARY

| Loudness Production Values | Loudness Production Values in db Re: Standard | Sum of Attenuator Settings | Average Attenuator Setting (Sum/6) | Sound Pressure Level Produced (80 − Average Attenuator Setting) |
|---|---|---|---|---|
| Standard | 0 $y_1$ | ________ | ________ | ________ $x_1$ |
| 2 times | 6 $y_2$ | ________ | ________ | ________ $x_2$ |
| 4 times | 12 $y_3$ | ________ | ________ | ________ $x_3$ |
| 8 times | 18 $y_4$ | ________ | ________ | ________ $x_4$ |

## Evaluation Form

# THE DYNAMICS OF HEARING AND THE LOUDNESS SCALE

(Submit this form with your laboratory report.)

1. The laboratory report required about ______ minutes to complete.

2. The experiment required about ______ minutes to complete.

3. The following malfunctions of the equipment occurred:

4. Other features of the experiment which caused difficulty were:

5. This experiment was conducted in section number ______.

# MEDIATED GENERALIZATION OF AN OPERANT RESPONSE TO VERBAL STIMULI

Stimulus generalization was demonstrated in a prior experiment in this way. After a response had been reinforced in the presence of an $S^D$, *S* was presented with a series of stimuli, produced by systematically varying one of the physical properties of the $S^D$; these variants of the $S^D$ were found to evoke the conditioned response. Stimulus generalization can also be observed, however, when stimuli are presented that are not simply variants of the $S^D$ and, indeed, have few properties in common with it. In the first kind of generalization, stimuli other than the $S^D$ will control the conditioned response to the degree that they share physical properties in common with the $S^D$. In the second kind of generalization, this prediction cannot safely be made; a stimulus quite different from the $S^D$ may control the conditioned response more than some other stimulus that has many properties in common with the $S^D$. As an example of this second kind of generalization, if an English-speaking adult is conditioned to emit a response (e.g., keypress) to the stimulus word CRY, the response will often be evoked by the word BAWL, but rarely by the word CUR. The term "mediated generalization" has been adopted for this behavioral phenomenon, because it has been suggested (by Osgood, 1952, among others) that words like CRY and BAWL elicit a common pattern of internal responses. The pattern of responses produces, in turn, a complex stimulus; the stimulus evokes the observed response. Thus, in the present example, the postulated response pattern intervenes—or mediates—between the presentation of CRY or BAWL and the emission of keypress.

The present experiment employs the minimum latency (reaction time) of a human operant as a dependent variable for examining mediated generalization among synonyms, antonyms, and homonyms.

## METHOD

### SUBJECTS

One experimentally naive college student (*S*) and two experimenters ($E_1$ and $E_2$) are required.

### APPARATUS

1. The stimuli for this experiment comprise two sets of words. Each set contains 36 words, including 12 presentations of a critical word

(e.g., BAWL) and 4 presentations of each of the following test words: a synonym of the critical word (CRY), an antonym (LAUGH), a homonym (BALL), and three control words (CUR, LUNCH, RAIL). The control words are selected to resemble the test words visually. Each word in a set is printed in large capital letters on a page in the Manual. The first set appears on odd-numbered pages, the second set on even-numbered pages.

2. A telegraph key and a double-pole switch, operated by S and $E_1$ respectively, are wired in series with a chronoscope (timer). $E_1$'s switch is also wired in series with a desk lamp. When $E_1$ closes the switch, the light goes on, illuminating a stimulus page. When S's key is also depressed, the chronoscope starts; when S's key is released, the chronoscope stops.

3. For each of the two sets of words, a Test Schedule and Data Form is provided in this Manual.

## PROCEDURE

### ADJUSTING THE EQUIPMENT

1. $E_1$ makes certain that the stimulus pages cannot be read when all the lights in the room are turned off.

2. $E_2$ ensures that the chronoscope and the lamp are plugged into the outlet box or wall socket and are turned on.

3. $E_1$ ensures that the chronoscope begins to time only when both S's key and $E$'s switch are closed and not otherwise. He ensures that $E$'s switch independently controls the lamp.

4. Finally, $E_1$ verifies that the reset lever or button on the chronoscope resets the dial to zero.

The chronoscope will be damaged if it is timing when the reset lever is depressed.

### TESTING FOR MEDIATED GENERALIZATION

1. $E_1$ grasps the Manual along a side edge and places it on a table so that the stimulus pages rest on their bottom edge, facing S. The Manual is kept in the same position throughout the experiment. After the first set of words is presented, starting with an odd-numbered page, the Manual is inverted and the second set is presented, starting with an even-numbered page and proceeding in reverse order *toward the front of the Manual.*

2. $E_1$ instructs S as follows: "Please depress your telegraph key and look directly at this page, which now displays the critical word for the first part of the experiment. In a moment the overhead lights will be turned off, and I will say 'ready'; then I will turn on the

desk lamp, and a test page will be visible. If the page contains this critical word, do nothing: if any other word is visible, however, lift your finger from the key as quickly as possible. Do not depress the key again until my colleague says 'next.'"

3. $E_2$ takes the Data Form corresponding to the set of words in use and places it next to the chronoscope. He turns off the overhead light and then resets the chronoscope.

4. $E_1$ says "ready" and then closes his switch, illuminating the first page (containing the critical word). If S responds to this or any other presentation of the critical word throughout the experiment, $E_2$ admonishes him and notes this in the Data Form.

5. $E_2$ says "next." At this signal, $E_1$ turns off the lamp and turns to the next page. Meanwhile, $E_2$ promptly resets the chronoscope. To ensure that the chronoscope is never reset while timing, $E_2$ operates the reset lever only when the desk lamp is off.

6. $E_1$ says "ready" and turns on the lamp again. After S responds, $E_2$ records the reading of the chronoscope on the Data Form, in the blank adjacent to the word that has just been presented. Then $E_2$ says "next," and Steps 5 and 6 are repeated until all 36 words in the first set have been presented.

7. After the first set of words has been completed, S is given a rest of about five minutes. Then the entire procedure is repeated with the second set of words. When this set is completed, the purpose of the experiment is explained to S.

## RESULTS

1. For each of the two sets of words, prepare a bar graph that shows the average reaction time obtained with each type of word, as calculated at the bottom of the Data Form.

2. Compare the average reaction times of the synonym, antonym, and homonym with their respective control words. Do your findings provide evidence for mediated generalization over and above simple stimulus generalization?

## DISCUSSION

Consider the following problems when discussing your results.

1. What is the function of the control words in this experiment? What do your measurements for these words reveal about generalization under the conditions of the experiment?

(e.g., BAWL) and 4 presentations of each of the following test words: a synonym of the critical word (CRY), an antonym (LAUGH), a homonym (BALL), and three control words (CUR, LUNCH, RAIL). The control words are selected to resemble the test words visually. Each word in a set is printed in large capital letters on a page in the Manual. The first set appears on odd-numbered pages, the second set on even-numbered pages.

2. A telegraph key and a double-pole switch, operated by S and $E_1$ respectively, are wired in series with a chronoscope (timer). $E_1$'s switch is also wired in series with a desk lamp. When $E_1$ closes the switch, the light goes on, illuminating a stimulus page. When S's key is also depressed, the chronoscope starts; when S's key is released, the chronoscope stops.

3. For each of the two sets of words, a Test Schedule and Data Form is provided in this Manual.

## PROCEDURE

### ADJUSTING THE EQUIPMENT

1. $E_1$ makes certain that the stimulus pages cannot be read when all the lights in the room are turned off.

2. $E_2$ ensures that the chronoscope and the lamp are plugged into the outlet box or wall socket and are turned on.

3. $E_1$ ensures that the chronoscope begins to time only when both S's key and *E*'s switch are closed and not otherwise. He ensures that *E*'s switch independently controls the lamp.

4. Finally, $E_1$ verifies that the reset lever or button on the chronoscope resets the dial to zero.
The chronoscope will be damaged if it is timing when the reset lever is depressed.

### TESTING FOR MEDIATED GENERALIZATION

1. $E_1$ grasps the Manual along a side edge and places it on a table so that the stimulus pages rest on their bottom edge, facing S. The Manual is kept in the same position throughout the experiment. After the first set of words is presented, starting with an odd-numbered page, the Manual is inverted and the second set is presented, starting with an even-numbered page and proceeding in reverse order *toward the front of the Manual.*

2. $E_1$ instructs S as follows: "Please depress your telegraph key and look directly at this page, which now displays the critical word for the first part of the experiment. In a moment the overhead lights will be turned off, and I will say 'ready'; then I will turn on the

desk lamp, and a test page will be visible. If the page contains this critical word, do nothing: if any other word is visible, however, lift your finger from the key as quickly as possible. Do not depress the key again until my colleague says ‘next.’”

3. $E_2$ takes the Data Form corresponding to the set of words in use and places it next to the chronoscope. He turns off the overhead light and then resets the chronoscope.

4. $E_1$ says “ready” and then closes his switch, illuminating the first page (containing the critical word). If S responds to this or any other presentation of the critical word throughout the experiment, $E_2$ admonishes him and notes this in the Data Form.

5. $E_2$ says “next.” At this signal, $E_1$ turns off the lamp and turns to the next page. Meanwhile, $E_2$ promptly resets the chronoscope. To ensure that the chronoscope is never reset while timing, $E_2$ operates the reset lever only when the desk lamp is off.

6. $E_1$ says “ready” and turns on the lamp again. After S responds, $E_2$ records the reading of the chronoscope on the Data Form, in the blank adjacent to the word that has just been presented. Then $E_2$ says “next,” and Steps 5 and 6 are repeated until all 36 words in the first set have been presented.

7. After the first set of words has been completed, S is given a rest of about five minutes. Then the entire procedure is repeated with the second set of words. When this set is completed, the purpose of the experiment is explained to S.

## RESULTS

1. For each of the two sets of words, prepare a bar graph that shows the average reaction time obtained with each type of word, as calculated at the bottom of the Data Form.

2. Compare the average reaction times of the synonym, antonym, and homonym with their respective control words. Do your findings provide evidence for mediated generalization over and above simple stimulus generalization?

## DISCUSSION

Consider the following problems when discussing your results.

1. What is the function of the control words in this experiment? What do your measurements for these words reveal about generalization under the conditions of the experiment?

2. What arguments may be advanced for considering that the longer latency of responding to the homonyms is evidence of mediated generalization on the one hand or evidence of simple stimulus generalization on the other?

3. A consumer-research bureau conducts a survey and discovers that a successful advertising campaign for Tide Soap was also followed by increased sales for Surf Flakes, although sales for all other brands had declined. Discuss this finding in the light of the present experiment.

4. Sartre names a harassed character "Orestes"; MacLeish calls the suffering protagonist of his play "J.B."; and Skinner calls the philosopher in his novel "Castle." Each of these authors is attempting to utilize mediated generalization to achieve certain ends. What are these ends and how are they achieved? (For an experimental analysis of this technique, see the article by Staats and Staats, 1957.)

### References

Osgood, C. E. The nature and measurement of meaning. *Psychological bulletin*, 1952, 49, 197–237. Bobbs-Merrill Reprint, P-266.

Staats, A., and Staats, Carolyn. Meaning established by classical conditioning. *Journal of experimental psychology*, 1957, *54*, 74–80. Bobbs-Merrill Reprint, P-333.

Name ______________________ Lab Hour ______________

Laboratory Instructor ______________ Date ______________

## Test Schedule and Data Form

### WORD SET I

Critical word . . . . MALE

| | | | |
|---|---|---|---|
| Synonym . . . | MAN | Control word S . | MAP |
| Antonym . . . | GIRL | Control word A . | BRIG |
| Homonym . . . | MAIL | Control word H . | MAUL |

| Plate No. | Word | Reaction Time (Seconds) | Plate No. | Word | Reaction Time (Seconds) |
|---|---|---|---|---|---|
| 1 | MALE | | 19 | GIRL | |
| 2 | BRIG | | 20 | MAUL | |
| 3 | MAIL | | 21 | MALE | |
| 4 | GIRL | | 22 | MAP | |
| 5 | BRIG | | 23 | MAIL | |
| 6 | MALE | | 24 | MAUL | |
| 7 | MAN | | 25 | MALE | |
| 8 | MALE | | 26 | MAN | |
| 9 | MALE | | 27 | MALE | |
| 10 | MAIL | | 28 | MAP | |
| 11 | MAUL | | 29 | MAIL | |
| 12 | MAN | | 30 | MAP | |
| 13 | MAP | | 31 | MALE | |
| 14 | GIRL | | 32 | MALE | |
| 15 | MALE | | 33 | MAUL | |
| 16 | MALE | | 34 | BRIG | |
| 17 | MAN | | 35 | MALE | |
| 18 | BRIG | | 36 | GIRL | |

Average Reaction Times (Seconds)

| | Synonym | Antonym | Homonym | Control S | Control A | Control H |
|---|---|---|---|---|---|---|
| Sum | | | | | | |
| ÷ 4<br>Average | | | | | | |

Name ______________________ Lab Hour ______________________

Laboratory Instructor ______________ Date ______________________

## Test Schedule and Data Form

## WORD SET 2

Critical word . . . . BAWL

| | | | |
|---|---|---|---|
| Synonym . . . . | CRY | Control word S . . | CUR |
| Antonym . . . | LAUGH | Control word A . | LUNCH |
| Homonym . . . | BALL | Control word H . | RAIL |

| Plate No. | Word | Reaction Time (Seconds) | Plate No. | Word | Reaction Time (Seconds) |
|---|---|---|---|---|---|
| 1 | BAWL | ______ | 19 | BAWL | ______ |
| 2 | LAUGH | ______ | 20 | RAIL | ______ |
| 3 | BALL | ______ | 21 | BALL | ______ |
| 4 | CRY | ______ | 22 | CUR | ______ |
| 5 | BAWL | ______ | 23 | LAUGH | ______ |
| 6 | BAWL | ______ | 24 | CUR | ______ |
| 7 | CUR | ______ | 25 | BAWL | ______ |
| 8 | RAIL | ______ | 26 | LUNCH | ______ |
| 9 | LAUGH | ______ | 27 | CRY | ______ |
| 10 | BAWL | ______ | 28 | RAIL | ______ |
| 11 | LUNCH | ______ | 29 | CRY | ______ |
| 12 | BAWL | ______ | 30 | BAWL | ______ |
| 13 | LUNCH | ______ | 31 | BAWL | ______ |
| 14 | CUR | ______ | 32 | BALL | ______ |
| 15 | CRY | ______ | 33 | BAWL | ______ |
| 16 | BAWL | ______ | 34 | BALL | ______ |
| 17 | BAWL | ______ | 35 | LAUGH | ______ |
| 18 | RAIL | ______ | 36 | LUNCH | ______ |

Average Reaction Times (Seconds)

| | Synonym | Antonym | Homonym | Control S | Control A | Control H |
|---|---|---|---|---|---|---|
| Sum | ______ | ______ | ______ | ______ | ______ | ______ |
| ÷ 4 | | | | | | |
| Average | ______ | ______ | ______ | ______ | ______ | ______ |

# MALE

# LUNCH

# BRIG

# LAUGH

# MAIL

BALL

# GIRL

BAWL

# BRIG

# BALL

# MALE

# BAWL

# MAN

BAWL

# MALE

# CRY

# MALE

# RAIL

# MAIL

# CRY

# MAUL

# LUNCH

# M:AN

# BAWL

# MAP

# CUR

# GIRL

# LAUGH

# MALE

# CU:R

# MALE

# BALL

# MAN

# RAIL

# BRIG

BAWL

# GIRL

# RAIL

# MAUL

BAWL

# MALE

# BAWL

# MAP

# CRY

# MAIL

# CUR

# MAUL

# LUNCH

# MALE

BAWL

# MAN

# LUNCH

# MALE

# BAWL

# M:AP

# LAUGH

# MAIL

# RAIL

# MAP

# CUR

# MALE

# BAWL

# MALE

# BAWL

# MAUL

# CRY

# BRIG

# BALL

# MALE

# LAUGH

# GIRL

# BAWL

## Evaluation Form

# MEDIATED GENERALIZATION OF AN OPERANT RESPONSE TO VERBAL STIMULI

(Submit this form with your laboratory report.)

1. The laboratory report required about ______ minutes to complete.
2. The experiment required about ______ minutes to complete.
3. The following malfunctions of the equipment occurred:

4. Other features of the experiment which caused difficulty were:

5. This experiment was conducted in section number ______.

# COLLATERAL CONTROL OF DISCRIMINATIVE VERBAL BEHAVIOR: AN EXPERIMENT IN SOCIAL INFLUENCE

In the experiment on verbal chaining, responding was under the discriminative control of verbal stimuli provided by preceding responses. On the other hand, in the experiments on stimulus generalization, the auditory threshold, and the loudness scale, responding was largely under the discriminative control of nonverbal stimuli.

This experiment examines estimates of stimulus magnitude made under the competing control of both verbal and nonverbal discriminative stimuli. The control exercised by nonverbal stimuli is minimized by employing the autokinetic phenomenon—the apparent movement of a stationary point of light in a darkened room. The control exercised by verbal stimuli is provided by an experimenter's accomplice, who announces prearranged estimates of stimulus magnitude; this control is enhanced by introducing the accomplice as a trained subject.

The purpose of the present experiment is to determine whether the introduction of social influence—that is, the accomplice's spoken estimates—will change the subject's estimates of the nonverbal stimulus and, if so, whether this change will be maintained when the social influence is removed.

## METHOD

### SUBJECTS

One experimentally naive college student ($S$) and two experimenters ($E_1$ and $E_2$) are required. $E_2$ serves as an accomplice and is not acquainted with $S$.*

### APPARATUS

1. The apparatus consists of a wooden screen, containing a pinhole and a small light bulb mounted behind the hole.

2. Slips of paper are provided for recording the estimates made by $S$ and $E_2$. These slips, numbered from 1–90, are prepared by removing the pages marked "Distance Estimates" from this Manual and tearing them along the lines ruled horizontally and vertically.

3. A Data Form is provided for each of the three experimental

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* See the comments on "Employing Subjects in Research" in the Guide to Original Research in this Manual.

conditions. The distance estimates initially recorded on the numbered slips are transcribed onto the Data Forms.

## PROCEDURE

### OBTAINING INITIAL DISTANCE ESTIMATES

1. $E_1$ brings in a naive subject, who has been told that he will participate in an experiment in "perception." $E_1$ seats the subject in a completely darkened room on a chair or stool facing the screen. S is never permitted to see any part of the room, including the apparatus, until after the experiment.

2. $E_1$ sits behind the screen, recording the distance estimates and operating a switch that turns the light on and off.

3. $E_1$ instructs S as follows: "When you say 'ready,' I will turn on a small point of light; after a short time the light will start to move. As soon as you see it move, say 'move.' A few seconds later the light will disappear. Then you are to tell me the distance it moved in inches. Try to make your estimates as accurate as possible. Okay, tell me when you are ready for the first trial."

4. When S gives the ready signal, $E_1$ turns on the light, waits until S reports that it is moving, waits five seconds more, and then turns off the light. $E_1$ records S's estimate on the first data slip. If no movement is reported in 30 seconds, $E_1$ extinguishes the light and records zero movement. Thirty estimates are recorded on the data slips in this first experimental condition.

### INTRODUCING SOCIAL INFLUENCE

1. S is then told that another subject is to be brought in for the second part of the experiment. $E_1$ instructs S to close his eyes, in order to remain accustomed to the dark, and to remain seated exactly as he is. $E_1$ takes the data slips and leaves S in the darkened room, shutting the door behind him as he leaves.

2. $E_1$ meets $E_2$ outside the room, and they compute the average of S's distance estimates. They then decide on an average for the estimates to be given by $E_2$ which is either greater or less than that already given by S.

3. $E_1$ takes $E_2$ into the darkened room and introduces him to S as a person who has experience in making distance estimates. For example, $E_2$ is introduced as a former subject or as a graduate student doing his doctoral dissertation on vision. $E_1$ states that $E_2$ is present so that the estimates of an expert and a novice can be obtained under the same conditions. $E_2$ is seated beside S.

4. The stimulus is turned on as soon as S and $E_2$ are ready, and both estimate its movement. Only S calls out "move," and the light

remains on for about five seconds thereafter. $E_2$ and S are instructed to give their estimates as their names are called. Each time, $E_1$ reverses the order in which the names are called, making sure to record the pairs of estimates in a consistent order on each data slip. $E_2$ varies his estimates around the average estimate previously agreed upon. Thirty pairs of estimates are obtained in this experimental condition.

### ASSESSING THE PERSISTENCE OF SOCIAL INFLUENCE

1. $E_1$ dismisses $E_2$ and requests S to remain for another series of estimates, since he "has had less experience in these judgments." A final set of thirty estimates is then obtained. At the end of the experiment, the apparatus is shown to S, and he is given a complete explanation of the experiment and the reasons for the deception.

## RESULTS

1. Prepare a graph for each of the three experimental conditions, plotting average-distance estimates as a function of successive blocks of five estimates. Plot the data for S and $E_2$ separately in the graph that depicts the estimates in the second experimental condition.

2. Describe the evidence for an effect of social influence in your experiment. If the effect was observed in the second experimental condition, did it persist during the third?

## DISCUSSION

Consider the following problems when discussing your results.

1. This generalization has arisen from much research in social psychology on judgments and attitudes: "Suggestibility varies directly with the ambiguity of the situation." Formulate this generalization in terms of collateral sources of control over verbal behavior.

2. Laboratory experiments on social influence, such as the one you have just conducted, are often cited as prototypes of the conditions under which prejudices are acquired and maintained in society. What features of your experiment are relevant to this problem? In what ways does this experiment fail to consider other important variables in the social setting? (See Asch, 1958, and Sherif, 1958, for discussions of social influence in laboratory experiments and in society.)

## References

Asch, S. Effects of group pressure upon the modification and distortion of judgments. In Maccoby, Eleanor, Newcomb, T. M., and Hartley, E. L. (eds.), *Readings in social psychology*. New York: Holt & Co., 1958, pp. 174–182.

Sherif, M. Group influence upon the formation of norms and attitudes. In Maccoby, Eleanor, Newcomb, T. M., and Hartley, E. L. (eds.), *Readings in social psychology*. New York: Holt & Co., 1958, pp. 219–232.

## Data Slips for Distance Estimates

### FIRST EXPERIMENTAL CONDITION

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 4 | 5 | 6 |
| 7 | 8 | 9 |
| 10 | 11 | 12 |
| 13 | 14 | 15 |
| 16 | 17 | 18 |
| 19 | 20 | 21 |
| 22 | 23 | 24 |
| 25 | 26 | 27 |
| 28 | 29 | 30 |

## SECOND EXPERIMENTAL CONDITION

| | | |
|---|---|---|
| 31 | 32 | 33 |
| 34 | 35 | 36 |
| 37 | 38 | 39 |
| 40 | 41 | 42 |
| 43 | 44 | 45 |
| 46 | 47 | 48 |
| 49 | 50 | 51 |
| 52 | 53 | 54 |
| 55 | 56 | 57 |
| 58 | 59 | 60 |

## THIRD EXPERIMENTAL CONDITION

| | | |
|---|---|---|
| 61 | 62 | 63 |
| 64 | 65 | 66 |
| 67 | 68 | 69 |
| 70 | 71 | 72 |
| 73 | 74 | 75 |
| 76 | 77 | 78 |
| 79 | 80 | 81 |
| 82 | 83 | 84 |
| 85 | 86 | 87 |
| 88 | 89 | 90 |

Name ______________________ Lab Hour ______________

Laboratory Instructor ____________ Date ______________

## Data Form

## FIRST EXPERIMENTAL CONDITION

| Stimulus No. | Estimate (Inches) | Stimulus No. | Estimate (Inches) |
|---|---|---|---|
| 1 | ______ | 16 | ______ |
| 2 | ______ | 17 | ______ |
| 3 | ______ | 18 | ______ |
| 4 | ______ | 19 | ______ |
| 5 | ______ | 20 | ______ |
| Sum | ______ | Sum | ______ |
| ÷ 5 | | ÷ 5 | |
| Average | ______ | Average | ______ |
| 6 | ______ | 21 | ______ |
| 7 | ______ | 22 | ______ |
| 8 | ______ | 23 | ______ |
| 9 | ______ | 24 | ______ |
| 10 | ______ | 25 | ______ |
| Sum | ______ | Sum | ______ |
| ÷ 5 | | ÷ 5 | |
| Average | ______ | Average | ______ |
| 11 | ______ | 26 | ______ |
| 12 | ______ | 27 | ______ |
| 13 | ______ | 28 | ______ |
| 14 | ______ | 29 | ______ |
| 15 | ______ | 30 | ______ |
| Sum | ______ | Sum | ______ |
| ÷ 5 | | ÷ 5 | |
| Average | ______ | Average | ______ |

Name ______________________ Lab Hour ______________

Laboratory Instructor ___________ Date ________________

## Data Form

## SECOND EXPERIMENTAL CONDITION

| Stimulus No. | *S*'s Estimate | $E_2$'s Estimate | Stimulus No. | *S*'s Estimate | $E_2$'s Estimate |
|---|---|---|---|---|---|
| 31 | ______ | ______ | 46 | ______ | ______ |
| 32 | ______ | ______ | 47 | ______ | ______ |
| 33 | ______ | ______ | 48 | ______ | ______ |
| 34 | ______ | ______ | 49 | ______ | ______ |
| 35 | ______ | ______ | 50 | ______ | ______ |
| Sum | ______ | ______ | Sum | ______ | ______ |
| ÷ 5 | | | ÷ 5 | | |
| Average | ______ | ______ | Average | ______ | ______ |
| 36 | ______ | ______ | 51 | ______ | ______ |
| 37 | ______ | ______ | 52 | ______ | ______ |
| 38 | ______ | ______ | 53 | ______ | ______ |
| 39 | ______ | ______ | 54 | ______ | ______ |
| 40 | ______ | ______ | 55 | ______ | ______ |
| Sum | ______ | ______ | Sum | ______ | ______ |
| ÷ 5 | | | ÷ 5 | | |
| Average | ______ | ______ | Average | ______ | ______ |
| 41 | ______ | ______ | 56 | ______ | ______ |
| 42 | ______ | ______ | 57 | ______ | ______ |
| 43 | ______ | ______ | 58 | ______ | ______ |
| 44 | ______ | ______ | 59 | ______ | ______ |
| 45 | ______ | ______ | 60 | ______ | ______ |
| Sum | ______ | ______ | Sum | ______ | ______ |
| ÷ 5 | | | ÷ 5 | | |
| Average | ______ | ______ | Average | ______ | ______ |

Name ______________________ Lab Hour ______________

Laboratory Instructor ____________ Date ______________

Data Form

## THIRD EXPERIMENTAL CONDITION

| Stimulus No. | Estimate (Inches) | Stimulus No. | Estimate (Inches) |
|---|---|---|---|
| 61 | | 76 | |
| 62 | | 77 | |
| 63 | | 78 | |
| 64 | | 79 | |
| 65 | | 80 | |
| Sum | | Sum | |
| ÷ 5 | | ÷ 5 | |
| Average | | Average | |
| 66 | | 81 | |
| 67 | | 82 | |
| 68 | | 83 | |
| 69 | | 84 | |
| 70 | | 85 | |
| Sum | | Sum | |
| ÷ 5 | | ÷ 5 | |
| Average | | Average | |
| 71 | | 86 | |
| 72 | | 87 | |
| 73 | | 88 | |
| 74 | | 89 | |
| 75 | | 90 | |
| Sum | | Sum | |
| ÷ 5 | | ÷ 5 | |
| Average | | Average | |

## Evaluation Form

# COLLATERAL CONTROL OF DISCRIMINATIVE VERBAL BEHAVIOR: AN EXPERIMENT IN SOCIAL INFLUENCE

(Submit this form with your laboratory report.)

1. This laboratory report required about ______ minutes to complete.
2. The experiment required about ______ minutes to complete.
3. Features of the experiment which caused difficulty were:

4. This experiment was conducted in section number ______.

Experiment 11

# SELF-PERSUASION BY UNTRUE STATEMENTS MADE IN THE PRESENCE OF CUES FOR TRUTHFULNESS

In the previous experiment on social influence, the subject's verbal behavior was partially controlled by the verbal behavior of another individual, the experimenter's accomplice. Several steps were taken to ensure that the accomplice's estimates would appear to be under the discriminative control of the light rather than under the reinforcement control of persuading the subject to alter his estimates. Advertisers often use a similar procedure to persuade prospective buyers. For example, a television announcer wears a white coat and stethoscope in an attempt to indicate to the viewer that, like a doctor's opinion, the announcer's praise of some medical product is controlled by features of the product, not by the salary the announcer receives. These examples suggest the hypothesis that the more stimuli there are to indicate to a listener that the speaker is under discriminative control, the more the listener will be persuaded. Research in social psychology has provided strong support for this hypothesis (Hovland, Janis, and Kelley, 1953). The present experiment explores the further possibility that an individual can persuade himself, and that he will do so to the extent that he discriminates his own verbal behavior as under discriminative as opposed to reinforcement control.

An overview of the experiment is as follows. S performs a word task in which he crosses out some words and not others. Then, two lights of different colors are established as discriminative stimuli accompanying true and false statements in this way: S is instructed to make statements about himself which are true (characteristically under discriminative control) in the presence of one light, and false statements (characteristically under reinforcement control) in the presence of the other light. Next, S is directed to state aloud, in the presence of the "Truth Light," that he had crossed out a word that actually he had not crossed out. S is then asked to recall whether in fact he had crossed out that word during the word task. This procedure is repeated with both true and false directed statements made in the presence of the Truth Light and the Lie Light, about words that S had and had not crossed out previously. If self-persuasion takes place under the control of the lights, then S will be persuaded by his statements in the presence of the Truth Light; and he will believe, for example, that he crossed out words that in fact he did not cross out.

## METHOD

### SUBJECTS

One experimentally naive college student (*S*) and two experimenters ($E_1$ and $E_2$) are required.[*]

### APPARATUS

1. Assorted pieces of apparatus, facing away from S, are wired together so as to give the impression of instrumentation for speech analysis.

2. Located in front of S are a microphone and a panel containing two 60-watt light bulbs, one amber and one green. Both devices have wires running to the purported measuring equipment; wires from the panel are connected to switches that enable *E* to operate the lights independently.

3. Several forms are included in this Manual:
   a. A List of Words—some of which are to be crossed out by S during the word task.
   b. An Alphabetical Guide that specifies the words to be crossed out.
   c. A Personal Information Form to be filled out by S.
   d. A Recall Form on which S reports whether he crossed out each of the test words.
   e. A Test Schedule that specifies for $E_1$ and $E_2$ the order of presentation of lights, test words, and S's statements.
   f. A Data Form that enables $E_2$ to summarize S's performance on the recall task.

### PROCEDURE

#### ADMINISTERING THE WORD TASK

1. The subject is seated in a chair facing the light panel and the microphone. $E_1$ is seated in front of the measuring equipment. $E_2$ instructs S as follows: "This experiment is designed to see if lies can be detected from certain aspects of the human voice. You will be given a number of things to say into the microphone, and we will take various measurements on your voice as you do this. First, however, I would like you to complete a preliminary task. You are to draw a line through each word on this Word List that also appears in this Alphabetical Guide. Go through the Word List only

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[*] See the comments on "Employing Subjects in Research" in the Guide to Original Research in this Manual.

once, at your own speed, reading each word in turn and then checking to see if it occurs in the Alphabetical Guide."

2. After S has completed the word task as described, $E_2$ takes away the Guide and the List, gives S the Personal Information Form from his Manual, and asks S to fill out the form accurately and completely, "providing us with facts we can ask you about in testing lie detection."

### ESTABLISHING THE DISCRIMINATION

1. $E_2$ continues to give the instructions: "I will ask you questions, one at a time, based on the Information Form that you have just filled out. After I ask you each question, the equipment will be turned on, automatically illuminating one of the two colored lights in front of you, and you should answer the question into this microphone. Whenever the amber light is on, you are to answer my question truthfully; whenever the green light is on, you should make up an untrue answer to my question and speak it into the microphone as convincingly and as naturally as possible. Your answers should be complete statements. For example, I will ask 'What is your first name?' If the amber light is on, then you would answer 'My first name is X,' giving your real first name. If the green light is on, you would make up some other name. If you make a mistake or do not answer with a complete sentence, I will ask the same question again."

2. $E_2$ reads the first question from the completed Information Form. Then $E_1$ checks his own Information Form to determine whether there is a period after the number preceding the question. If there is, he turns on the amber light; if not, the green light.

3. S answers the question with a complete sentence, and then $E_1$ turns off the light. If S has responded correctly, lying when the green light was on or telling the truth when the amber light was on, $E_2$ proceeds to the next question. Otherwise the question is repeated.

### ADMINISTERING THE SELF-PERSUASION AND RECALL TASKS

1. $E_2$ continues as follows: "You will now make statements concerning some of the words you saw earlier. When I ask you to state that you crossed out a particular word—for example, if I say 'did-TREE'—you should wait until the equipment is turned on, and then make a statement of the form 'I did cross out the word TREE.' If I ask you to deny having crossed out a word—'did not-TREE'—you should say 'I did not cross out the word TREE.' Do not begin your statement until the equipment has been turned on, as indicated by the lights."

2. Without interruption, $E_2$ places the Recall Form in front of S and continues to instruct him: "We also need to know if you recall whether you crossed out the word that appeared in your statement. Therefore, after you have made your statement and the equipment has been turned off, enter the word in the first column of this form, and indicate in the second column whether or not you had crossed it out. In the third column, indicate how sure you are that you remember correctly by entering a number from 1 to 5 in accord with the scale listed at the head of the column. Note the example, TREE, which has already been filled in on the form."

3. $E_2$ then reads each word from the Test Schedule, as described in Step 1 above. $E_1$ uses the Test Schedule from his Manual to determine which of the two lights is to be turned on each time S makes his statement. As before, $E_1$ turns on the light when $E_2$ is through speaking and turns off the light when S is through speaking.

4. At the end of the experiment, the apparatus is shown to S, and he is given a complete explanation of the experiment and the reasons for the deception.

## RESULTS

In the last part of this experiment, S made twenty untrue statements about his past behavior on the word task—ten in the presence of a light that had previously accompanied true statements, and ten in the presence of a light that had previously accompanied false statements. If the Truth Light was effective in making S's statements self-persuasive, then the average confidence ratings for these ten words should reflect S's uncertainty about his true past behavior—that is, the ratings should be low relative to ratings for the ten words about which statements were made during the Lie Light. In some cases, false statements during the Truth Light may even have caused S to recall his past behavior incorrectly.

In order to determine whether your data reveal either of these effects of the Truth Light, enter next to each word on the Data Form the appropriate confidence rating from column 3 of the Recall Form. Each time that S's report in column 2 of the Recall Form does not agree with the corresponding entry in column 2 of the Data Form, place a minus in front of the adjacent confidence rating. Finally, compute the average score. (Note that this score is a measure of the net effect of the light and not an average rating of confidence.)

Present in Table 1 of your report the twenty confidence ratings that were obtained after untrue statements were made in the presence of the Truth Light and the Lie Light. Were S's confidence ratings of his recall lower after untrue statements in the presence of the Truth Light than after untrue statements in the presence of the Lie Light? Were there more instances of incorrect recall in the former case? In general, do your findings provide evidence of the effectiveness of the lights as discriminative stimuli for self-persuasion?

## DISCUSSION

Consider the following problems when discussing your results.

1. There are many ways of inducing someone to confess to something he has not, in fact, done. In the light of your results, what would be the objection to offering a person a large reward for a confession—if you wanted him to believe it as well as just say it?

2. In the Korean conflict, in contrast to previous wars, some prisoners came to believe their confessions of crimes that they had not, in fact, committed (Schein, 1956). It is also noteworthy that the confessions were obtained without obvious threat of punishment. How would you account for the prisoners' self-persuasion?

3. In an experiment by Festinger and Carlsmith (1959), subjects had to engage in a long and repetitive laboratory task. Each of the subjects in one group was then hired by the experimenter as an "assistant" and paid $1 to tell another student that the tasks were enjoyable and interesting. The subjects in a second group were hired for $20 to do the same thing. At a later time, all of the subjects were asked their actual attitude toward the tasks. What would you predict about the attitudes of the $1 subjects compared to the attitudes of the $20 subjects? What is the reasoning behind your prediction?

### References

Festinger, L., and Carlsmith, J. M. Cognitive consequences of forced compliance. *Journal of abnormal and social psychology,* 1959, 58, 203–210.

Hovland, C., Janis, I., and Kelley, H. *Communication and persuasion.* New Haven: Yale University Press, 1953.

Schein, E. H. The Chinese indoctrination program for prisoners of war: a study of attempted "brainwashing." In Maccoby, Eleanor, Newcomb, T. M., and Hartley, E. L. (eds.), *Readings in social psychology.* New York: Holt & Co., 1958, pp. 311–334.

Skinner, B. F. *Verbal behavior.* New York: Appleton-Century-Crofts, 1957 (esp. Chaps. 1, 2, 3, 5).

## Word List

Dog
Chair
Tree
Alice
Apple
John
Water
Dish
Car
Man
Cat
Table
Shrub
Betty
Orange
Irving
Milk
Cup
Train
Woman
Wolf
Couch
Grass
Carol
Grape

Harold
Beer
Spoon
Plane
Boy
Bear
Lamp
Flower
Doris
Banana
George
Juice
Fork
Carriage
Girl
Fox
Rug
Weed
Elaine
Watermelon
Fred
Wine
Knife
Bicycle
Male

Lion
Bed
Clover
Florence
Cantaloupe
Edward
Tea
Saucer
Tricycle
Female
Pig
Stool
Bush
Grace
Lemon
David
Coffee
Tumbler
Boat
Maiden
Sheep
Shelf
Hedge
Helen
Avocado

Carl
Whiskey
Plate
Ship
Lady
Cow
Sink
Plant
Ida
Tomato
Bob
Gingerale
Platter
Truck
Lad
Horse
Stove
Vine
Joan
Lime
Alan
Champagne
Kettle
Bus
Child

## Alphabetical Guide for Word Task

Alice
Avocado
Bear
Beer
Bob
Boy
Bush
Car
Carol
Carriage
Cat
Chair
Champagne
Child
Couch
Cow
Cup
David
Dog
Edward
Florence
Flower
Fork
George
Helen
Ida
John
Knife
Lemon
Lime
Lion
Maiden
Male
Orange
Plane
Plant
Platter
Rug
Shelf
Ship
Shrub
Stove
Tea
Tricycle
Tumbler
Vine
Watermelon
Whiskey
Wine
Woman

## Personal Information Form

1. What is your first name? ______________________
2 What is your age? ______________________
3. When is your birthday? ______________________
4. What is your mother's first name? ______________________
5 What is your father's first name? ______________________
6. What is your school address? ______________________
7. Do you wear glasses? ______________________
8 Do you wear hats? ______________________
9 What is your major field of study? ______________________
10 Are you generally favorable to sororities and fraternities? __________
11. What is your grade-point average? ______________________
12 In what city do your parents live? ______________________
13 What is your best academic subject? ______________________
14. Do you play bridge? ______________________
15. What is the name of the last movie you have seen? __________
16. Do you favor abolishing grades? ______________________
17 What is your favorite magazine? ______________________
18. What is your height? ______________________
19 What is the color of your eyes? ______________________
20 What is the color of your hair? ______________________
21. Can you drive a car? ______________________
22 What political party do you favor? ______________________
23. Have you taken any courses in calculus? ______________________
24 Do you consider yourself even-tempered? ______________________
25 Do you play chess? ______________________
26. What is your favorite work of fiction? ______________________
27. Have you been to Canada? ______________________
28 Have you been to Mexico? ______________________

29. What is your favorite type of music? ____________________

30. Did you watch television last night? ____________________

31 Have you ever flown in a jet? ____________________

32 Do you play a musical instrument? ____________________

33. What graduating class are you in? ____________________

34 Are you wearing a ring? ____________________

35. How many psychology courses have you taken? ____________________

36 What high school did you attend? ____________________

37 Are you married or engaged? ____________________

38 What foreign languages do you know? ____________________

39. What is your favorite sport? ____________________

40. Are you right- or left-handed? ____________________

41 Whom would you like to see as the next President of the United States? ____________________

42 Do you learn more from lectures or discussion sections? ____________________

43. What brand of toothpaste do you use? ____________________

44 What is the most important military service? ____________________

45. What was the main course at dinner last night? ____________________

46. Do you prefer hot or cold weather? ____________________

47 Who is your favorite actress? ____________________

48. Who is your favorite actor? ____________________

49. Are you an extrovert or an introvert? ____________________

50 What is man's most heinous crime? ____________________

## Recall Form

° 1 = Not sure at all 2 = Slightly sure 3 = Moderately sure
4 = Quite sure 5 = Absolutely sure

| (1) Word | (2) Did you cross it out? | °(3) How sure are you? | (1) Word | (2) Did you cross it out? | °(3) How sure are you? |
|---|---|---|---|---|---|
| (e.g., TREE) | (e.g., NO) | (e.g., 3) | — | — | — |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
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## Test Schedule

| Word | Statement | Light | Word | Statement | Light |
|---|---|---|---|---|---|
| Dog | Did | Truth A | Lion | Did not | Truth A |
| Alice | Did not | Lie G | Florence | Did | Lie G |
| Apple | Did | Truth A | Cantaloupe | Did not | Truth A |
| Man | Did not | Truth A | Female | Did | Truth A |
| Betty | Did | Truth A | Grace | Did not | Truth A |
| Orange | Did not | Truth A | Lemon | Did | Truth A |
| Milk | Did not | Lie G | Coffee | Did | Lie G |
| Woman | Did | Truth A | Maiden | Did not | Truth A |
| Wolf | Did | Lie G | Sheep | Did not | Lie G |
| Carol | Did not | Truth A | Helen | Did | Truth A |
| Beer | Did | Lie G | Whiskey | Did not | Lie G |
| Bear | Did not | Lie G | Cow | Did | Lie G |
| Banana | Did not | Lie G | Tomato | Did | Lie G |
| Juice | Did not | Truth A | Gingerale | Did | Truth A |
| Girl | Did | Lie G | Lad | Did not | Lie G |
| Fox | Did | Truth A | Horse | Did not | Truth A |
| Elaine | Did not | Lie G | Joan | Did | Lie G |
| Watermelon | Did | Lie G | Lime | Did not | Lie G |
| Wine | Did | Truth A | Champagne | Did not | Truth A |
| Male | Did not | Lie G | Child | Did | Lie G |

## Data Form

## CONFIDENCE RATINGS AFTER UNTRUE STATEMENTS

| Truth Light | | | Lie Light | | |
|---|---|---|---|---|---|
| Word | Actually Crossed Out? | Confidence Rating * | Word | Actually Crossed Out? | Confidence Rating * |
| Apple | No | ______ | Alice | Yes | ______ |
| Betty | No | ______ | Wolf | No | ______ |
| Orange | Yes | ______ | Bear | Yes | ______ |
| Carol | Yes | ______ | Girl | No | ______ |
| Fox | No | ______ | Male | Yes | ______ |
| Lion | Yes | ______ | Coffee | No | ______ |
| Female | No | ______ | Whiskey | Yes | ______ |
| Maiden | Yes | ______ | Tomato | No | ______ |
| Gingerale | No | ______ | Joan | No | ______ |
| Champagne | Yes | ______ | Lime | Yes | ______ |
| Sum | | ______ | Sum | | ______ |
| ÷ 10 = Average | | ______ | ÷ 10 = Average | | ______ |

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* The confidence ratings are negative for words that S recalled incorrectly.

Evaluation Form

# SELF-PERSUASION BY UNTRUE STATEMENTS MADE IN THE PRESENCE OF CUES FOR TRUTHFULNESS

(Submit this form with your laboratory report.)

1. The laboratory report required about ______ minutes to complete.

2. The experiment required about ______ minutes to complete.

3. Features of the experiment which caused difficulty were:

4. This experiment was conducted in section number ______.

# A GUIDE TO ORIGINAL RESEARCH

If you are given the assignment or option of conducting an experiment of your own design, you may find this guide helpful in formulating the problem and in implementing the research.

## FORMULATING A PROBLEM

There are many ways of arriving at a research problem and many reasons for conducting an experiment. Among them:

1. To evaluate hypotheses.
2. To indulge the investigator's curiosity about nature.
3. To try out a new method or technique.
4. To establish the existence of a behavioral phenomenon.
5. To explore the conditions under which a phenomenon occurs.[*]

Specific problems may be suggested to you by your own observations of behavior outside the laboratory, by your concern with some problem in behavioral engineering (such as education, therapy, or race relations), by your findings in experiments in this Manual, by your work in other psychology or social science courses, or by an examination of the professional literature.

## PREPARING A RESEARCH PROPOSAL

A concise but explicit research proposal enables your instructor to make substantive and detailed suggestions for improving the research. A proposal includes a description of: (1) the problem and related prior research; (2) the required apparatus and where it will be obtained; (3) the administration of the research, including where it will be conducted, the number and recruitment of subjects, and the duration and number of experimental sessions; (4) the experimental procedures, including measurement and control of variables; and (5) data presentation and statistical analysis.

## CONSULTING THE PROFESSIONAL LITERATURE

The psychological journals will be helpful either in selecting a problem or, if you have already selected one, in determining what other investigators have done in your problem area. Although it is sometimes helpful to browse through a journal that reports research in an area of interest to you, the most efficient way to search the literature is to go to the *Psychological abstracts* and look up a specific topic in the yearly index at the back of the bound volume. The index is extensively cross-referenced and will refer you to the relevant numbers of the abstracts in the volume; the abstracts, in turn, will refer you to the journal in which the complete article is located. The abstracts are also grouped together under general headings, and a table of contents is provided so you can browse through the abstracts as well. You may not understand all the statistical procedures employed in professional articles, but rarely will this prevent you from understanding the experiment. Your instructor can discuss the basic concepts of inferential statistics with you and give you any specific information you require for understanding the articles or conducting your own research.

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[*] This list is adapted from M. Sidman, *Tactics of scientific research* (New York: Basic Books, 1960).

Some of the textbooks and psychological journals that may also be helpful in selecting and pursuing a research problem are cited in the topical list below.

### ANIMAL LEARNING

1. Kimble, G. A. *Hilgard & Marquis' conditioning and learning*. New York: Appleton-Century-Crofts, 1961.
2. *Journal of the experimental analysis of behavior.*

### VERBAL LEARNING

1. Deese, J. *Human learning*. New York: McGraw-Hill, 1958.
2. *Journal of verbal learning and verbal behavior.*

### SENSORY MEASUREMENT

1. Geldard, F. *The human senses*. New York: Wiley, 1953.
2. Osgood, C. E. *Method and theory in experimental psychology*. New York: Oxford, 1953.
3. *Journal of comparative and physiological psychology.*

### PERCEPTION

1. Dember, W. *Psychology of perception*. New York: Holt & Co., 1960.
2. Beardslee, D. C., and Wertheimer, M. (eds.). *Readings in perception.* Princeton, N. J.: Nostrand, 1958.
3. *Journal of experimental psychology.*

### PERSONALITY

1. McLelland, D. *Studies in motivation*. New York: Appleton-Century-Crofts, 1955.

2. *Journal of personality.*
3. *Journal of abnormal and social psychology.*

SOCIAL BEHAVIOR

1. Maccoby, Eleanor, Newcomb, T. M., and Hartley, E. L. (eds.). *Readings in social psychology.* New York: Holt & Co., 1958.
2. *Journal of abnormal and social psychology.*

## OBTAINING APPARATUS FOR RESEARCH

Many experiments require apparatus that can be easily constructed or assembled. In fact, research in the personality and social areas often requires no more equipment than paper and pencil. Your instructor can direct you to sources in the literature for standardized tests and attitude scales that may save you the work of designing your own. For research requiring more elaborate instrumentation, your laboratory may have equipment, in addition to that used for the scheduled laboratory experiments, which may be employed or modified to suit your needs. Finally, it may be possible for you to work with equipment belonging to faculty members or graduate students who are willing to supervise the project or to make it a part of their own research.

## EMPLOYING SUBJECTS IN RESEARCH

If your research requires a few animal subjects, they can usually be provided. Experiments that require a large number of animal subjects, however, are difficult to conduct in an elementary laboratory and are not advised. If an experimentally naive animal is not required, you may be able to use the rat assigned to you for the experiments in this Manual. Observe the procedures for proper animal care, described in part at the front of this Manual. Poor animal care is a mark of poor research, and probably all major centers for animal research in psychology take elaborate measures for the care of infrahuman subjects. On the other hand, you should not consider the animal a pet or human being. Perhaps it is wisest to treat your animal subjects as you would vital pieces of instrumentation in your laboratory; they must be kept in perfect running condition or your measurements may be unsound.

If your research requires human subjects, they can often be obtained from among your friends. Requests to use members of campus and community organizations (such as fraternities, dormitories, public schools) should be approved by the course instructor. Also, a subject should never be deceived or discomforted without the express permission of the course instructor. He will grant this permission only if the degree of deception and discomfort is minor and necessary and if you will inform the subject fully about the nature of the experiment as soon as practical. It is not only good ethics but also good scientific practice to treat human subjects as well as possible. Unduly long, tedious, unpleasant, or poorly conducted experiments usually lead to "noisy" data; they make it more difficult for other students and faculty in psychology to gain the services of subjects; they leave fellow students with a poor attitude toward psychology, and may even discourage some from gaining further knowledge in this area. Subjects are willing to go to considerable inconvenience and to invest their trust in you as a scientist in order to advance your training, the discipline of psychology, and their knowledge. Every experiment you conduct should achieve these goals to some measure.

# COURSE-EVALUATION FORM

Toward the end of the term, your instructor will ask you to fill out this course-evaluation form and to submit it anonymously. The evaluation will be read by your instructor only after grades are reported and will enable him to improve the course in future terms.

1. Indicate your evaluation of the characteristics below, checking the appropriate column.

| Educational Value of the Experiments | Superior | Very Good | Good | Fair | Poor |
|---|---|---|---|---|---|
| Exp. 1. Operant Conditioning | | | | | |
| Exp. 2. Light-Dark Discrimination | | | | | |
| Exp. 3. Homogeneous Chains | | | | | |
| Exp. 4. Secondary Reinforcement | | | | | |
| Exp. 5. Verbal Chaining | | | | | |
| Exp. 6. Auditory Generalization | | | | | |
| Exp. 7. Auditory Thresholds | | | | | |
| Exp. 8. Loudness | | | | | |
| Exp. 9. Mediated Generalization | | | | | |
| Exp. 10. Social Influence | | | | | |
| Exp. 11. Self-Persuasion | | | | | |

2. According to the scale above, rate your laboratory instructor's teaching effectiveness: ________. (Instructor's name ____________________.)

3. Rate the lecturer's general teaching effectiveness: ________.

4. Rate the value of the course as a whole: ________.

5. Please describe features of the course which you consider particularly good or poor and offer any suggestions that you have for improving the course. Use the reverse side of this sheet.

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**Form No. 3.**

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The book is to be returned within the date stamped last.

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Form No. 4

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